The U.S. Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River

Gateways to Commerce

National Park Service - Rocky Mountain Region / United States Army Corps of Engineers

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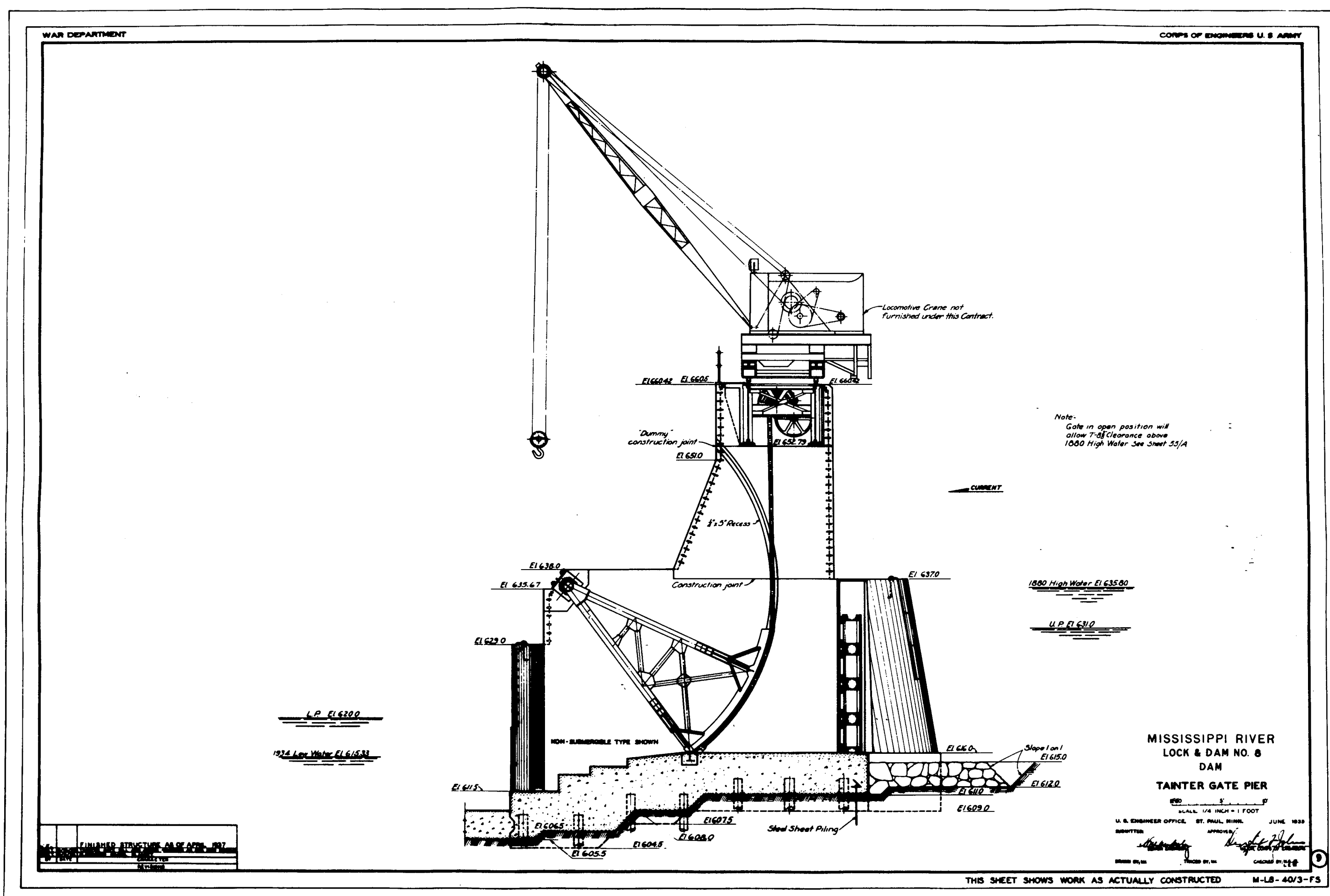
William Patrick O'Brien Mary Yeater Rathbun Patrick O'Bannon *Edited by Christine Whitacre*



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Front Cover Photograph: *Lock and Dam No. 6, Trempealeau, Wisconsin, December 1936. (U.S. Army Corps of Engineers, St. Paul District)*

Title Page Drawing: *Construction Drawing of Tainter Gate, Dam No. 8, June 1935. (U.S. Army Corps of Engineers, St. Paul District)*

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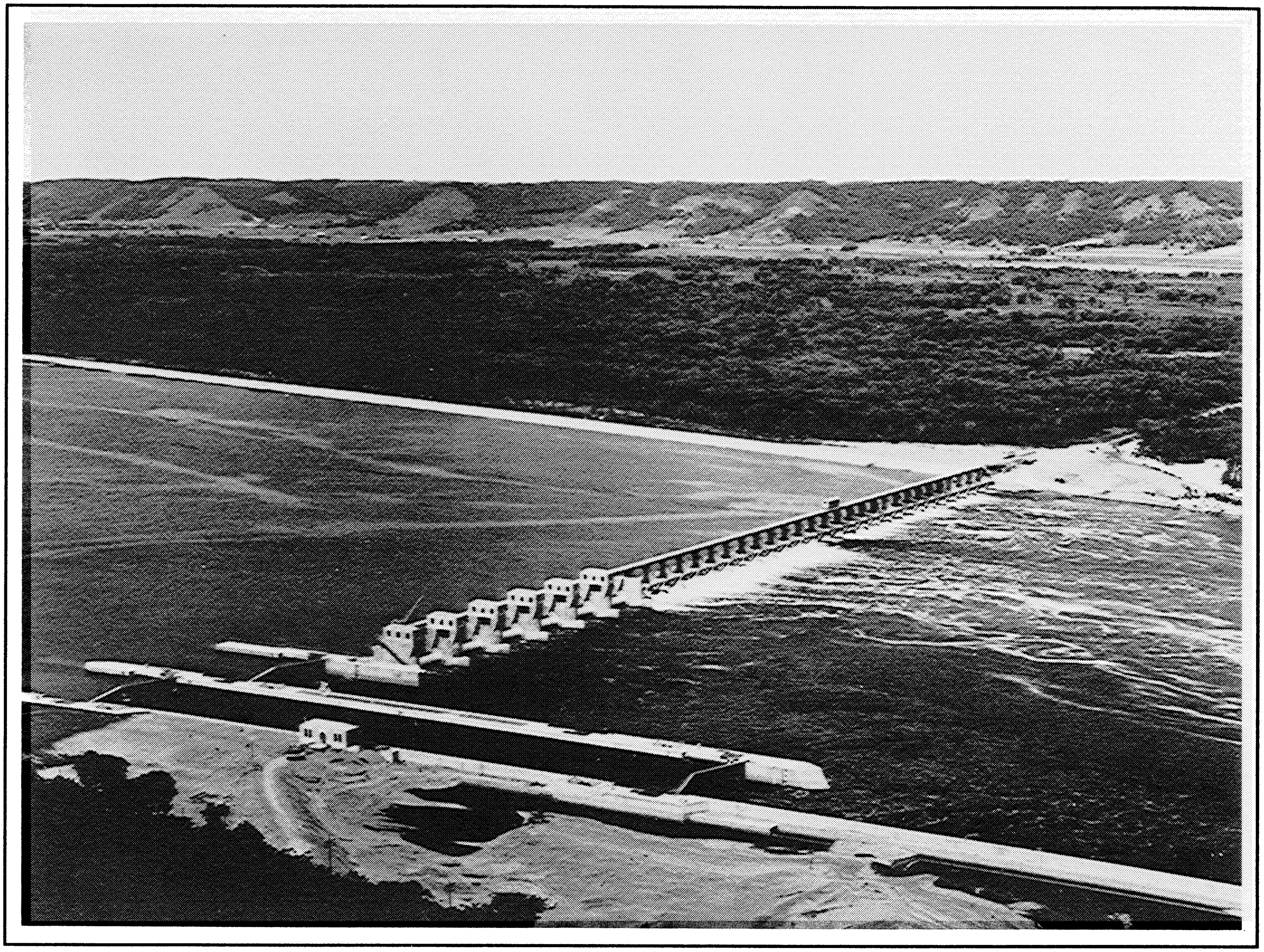


With the 9-Foot Channel Project, the U.S. Army Corps of Engineers transformed the free-flowing Upper Mississippi River into a series of "lakes" or slack-water pools. River water backs up behind the project's 29 dams, creating an equal number of pools. These pools ensure a minimum 9-foot navigable depth on the river. Although the dams require all river traffic to pass through locks, the system provides what the river in its natural state could not: dependable navigation on the Mississippi River. Lock and Dam No. 5A, 1937. (U.S. Army Corps of Engineers, St. Paul District)

Preface

That great poetic promoter of America, Philip Freneau, once stated that the Mississippi was the most impressive of rivers and that others failed to compare with its majesty and breadth. In the years between 1930 and 1940, the United States Army Corps of Engineers caused the upper reaches of this mighty stream to be turned into an intra-continental canal, regulated and controlled for the promotion of commerce. The project changed forever the Upper Mississippi River into a commercial canal, access to which remains in the hands of the American military, specifically the U.S. Army Corps of Engineers. As barges pass and seasons change, its impacts, both social and environmental, still vibrate up and down the riverine corridors of the Upper Mississippi Valley.

In 1986, the National Park Service's Rocky Mountain Regional Office entered into an agreement with the St. Paul District Office of the United States Army Corps of Engineers to produce Historic American Engineering Record (HAER) documentation of the locks and dams connected with Upper Mississippi River 9-Foot Channel Project in the St. Paul District. Four years later, 2 additional contracts between the National Park Service and the Corps of Engineers' Rock Island and St. Louis Districts allowed the National Park Service to complete documentation of the original 26-unit system from St. Paul, Minnesota, to St. Louis, Missouri. This HAER recordation project complemented the gigantic nature of the 9-foot channel itself, with hundreds of photographs, pages of history, and inventories. Those records, now stored as part of the Historic American Engineering Record archives in the Library of Congress, Washington, D.C., will provide future researchers access to the original elements of the 9-Foot Channel Project as built between 1930-1940.

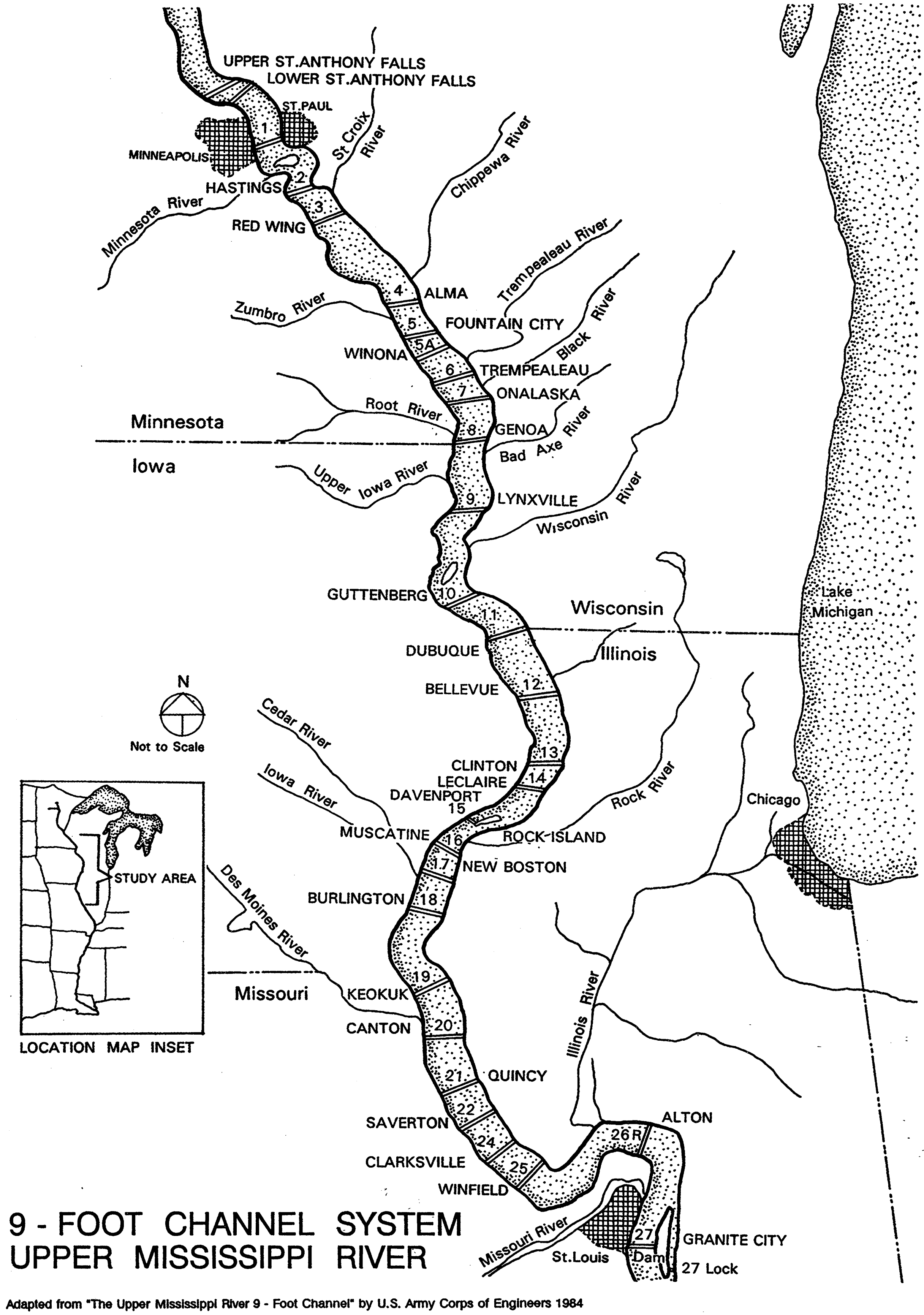
This study relies extensively on materials located in Record Group 77 of the National Archives. Repositories at Kansas City, Missouri; Chicago, Illinois; St. Louis, Missouri; and Washington, D.C., provided thousands of linear feet of records generated as a result of the 10-year undertaking. Researchers also consulted thousands of maps, working drawings, elevations, and similar materials in the St. Paul, Rock Island, and St. Louis Districts. Sixteen-millimeter film footage of construction, and extensive black and white photography also provided valuable period documentation.

Because of the huge nature of both the Upper Mississippi 9-Foot Channel Project and the equally huge amount of documentary material associated with its construction and administration, research was divided into three separate phases. In 1986-1987, I researched and wrote the history of the St. Paul District's section of the 9-Foot Channel Project while working as a historian with the Rocky Mountain Regional Office's division of the Historic Americans Building Survey/Historic American Engineering Record, under the direction of Gregory Kendrick, Chief of the History Unit. Photographed by Clayton Fraser, the St. Paul District study set the tone and structure for the project. After completion of the St. Paul history, I acted as general manager for the remainder of the research in the Rock Island and St. Louis Districts, contracting with Mary and Peter Rathbun of Rathbun and Associates for the Rock Island portion of the work in 1987, and Dr. Patrick O'Bannon of John Milner and Associates of Philadelphia, Pennsylvania, for the St. Louis portion of the study in 1988. After my transfer to the National Park Service's Denver Service Center in 1989, Christine Whitacre of the Rocky Mountain Regional Office accepted the enormous job of editing the materials from the three studies into the single volume presented here.

The 9-Foot Channel Project involves social, political, economic, military, environmental, and technological histories. It touches labor and ethnic issues, and portrays the end of the American Progressive Era and the beginnings of the New Deal. It involves the economics of the Upper Mississippi Valley, and vividly reflects the role of the military in domestic issues. The 9-Foot Channel Project's impact on the environment was of a magnitude rarely experienced since the famous Hetch Hetchy project of California in the second decade of the twentieth century. It demonstrates the evolution of technology and its impact on man and his environment. Unfortunately, the project's documents also reflect the history of the era selectively; women and minorities only appear as shadows in its saga when they appear at all. The 9-Foot Channel Project as built by the United States Army Corps of Engineers represents not only an astounding engineering feat--it accurately reflects the tenor of a nation and its feelings concerning society, politics, economics, labor, the military, technology, and the environment in those hard years before the Second World War.

The Upper Mississippi River 9-Foot Channel Project represents a subject of inquiry that has been taken for granted for a number of years. It offers exciting prospects for research in a number of historical fields. It is hoped that this general technological survey of the project's construction and its history will inspire others to continue in-depth research regarding the various subjects touched on in this narrative. In building on previous research, questioning each interpretation, and continuing the dialogue so necessary to historical thought, we may all contribute to that phenomenon known as historical research--that continual process of updating and reassessment that Belgian historian and educator Henri Pirenne so rightly called "the very proof of the progress of scholarship."

William Patrick O'Brien



The 9-Foot Channel Project created a fully navigable canal from Minneapolis/St. Paul to St. Louis and linked the Upper Midwest with New Orleans, a port offering access to Central and South American markets. Below St. Louis, the Mississippi River is navigable in its natural state. (Drawing: Catherine Colby, National Park Service)

Introduction

The Mississippi is well worth reading about. It is not a commonplace river, but on the contrary is in all ways remarkable.[1]

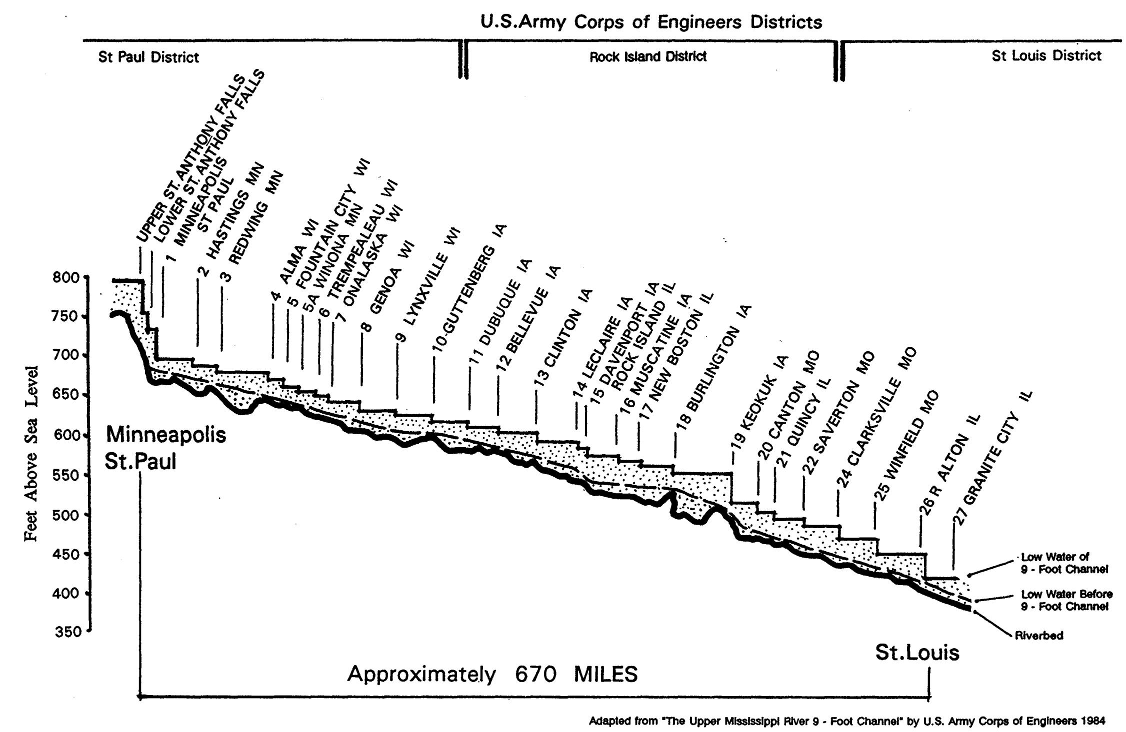
Mark Twain

Huckleberry Finn learned about the Mississippi River on a raft. Today, young boys are more likely to learn how to navigate the Upper Mississippi River from a computer program at a U.S. Army Corps of Engineers Visitor Center. Does our modern Huck Finn want to go from Hannibal to St. Louis? First, he must get past the dam at Saverton, Missouri. As he pushes a button, Huck watches the video screen as his computer-generated towboat passes through the upriver gates of a navigation lock. He pushes another button. The gates close and the water level in the lock drops several feet, until it is the same as the downriver side of the dam. Huck pushes yet another button. The downriver gates open, and the towboat cruises on down the Mississippi. But the trip is not over. Before he reaches St. Louis, Huck will also have to "lock through" at Clarksville, Winfield, Alton, and Granite City. Like its real-life counterparts, Huck's little towboat will have to repeat this process four more times.

Once, the Upper Mississippi River flowed freely. From its headwaters in upper Minnesota, there were no locks and dams to obstruct the river's path as it flowed through the forests and fields of the Upper Midwest. But the river was also temperamental. Compared to the Lower Mississippi, that stretch of the river below St. Louis made mighty by the combined waters of the Missouri and the Ohio Rivers, the Upper Mississippi River was unreliable. During times of flood, the Upper Mississippi was deep-flowing, but turbulent. More frequently, long dry spells made the river too shallow to navigate. The river's uncharted shoals and sand bars presented a constant danger. Equally dangerous were the "snags," trees that storms had washed from the river's banks into its waters. The Upper Mississippi was a challenge to all who plied its waters. And the travelers were many: Native Americans in birch bark canoes, French traders in pirogues, Army explorers in keelboats, lumbermen on log rafts, and enterprising steamboat captains who cautiously steered their paddlewheelers through the river's rapids. Whatever the craft, its success depended upon the river's ever-changing conditions, and the skill of its pilot.

Reflecting pride in engineering, the Corps of Engineers has built Visitor Centers at 9-Foot Channel Project sites. The displays highlight the history of the Corps, and the operations of the 9-Foot Channel. Lock and Dam No. 15. (Peter A. Rathbun)

The Upper Mississippi River 9-Foot Channel Project, which was designed and constructed by the U.S. Army Corps of Engineers between 1930 and 1940, has transformed the once free-flowing river into a slack-water navigation system. The system is often compared to a stairway. The "treads" are the slack-water lakes, or navigation pools, created by a series of dams across the river. The "risers" are the locks which, through their changing water levels, carry the boats from one pool to the next. From the largest barge to the smallest raft, every vessel traveling the Upper Mississippi River has to navigate this system of locks and dams. While passage through the locks is time-consuming, it provides what the river in its natural state could not: a dependable 9-foot navigational depth on the Upper Mississippi.



CROSS SECTION DIAGRAM OF 9 - FOOT CHANNEL

In section, the Upper Mississippi River 9-Foot Channel resembles a water "stairway." Each lock and dam is situated higher than the one below it. Instead of the river channel becoming more shallow as one moves upriver, a 9-foot depth is regularly maintained from lock to lock, enabling fully-loaded, commercial barges and tows to use the river without having to transfer cargo to smaller and smaller barges as they proceed upriver. (Drawing: Catherine Colby, National Park Service)

As originally planned in the 1920s, the 9-Foot Channel Project was comprised of 26 locks and dams and their associated pools that extended from St. Paul, Minnesota, south to Alton, Illinois. In 1937, Congress authorized a 4.6 mile extension of the original project at its upstream end, and two additional complexes were built: the Upper St. Anthony Falls Lock and Dam, and the Lower St. Anthony Falls Lock and Dam. In 1953, the system was again expanded by the construction of Lock No. 27 and the Chain of Rocks Canal, which extended the channel to St. Louis. Dam No. 27, also known as the Chain of Rocks Dam, was finished in 1964. As now completed, the 9-foot channel on the Upper Mississippi is made up of 29 lock and dam complexes. The system extends across a 669-mile stretch of river which, between Minneapolis and St. Louis, has a fall of approximately 400 feet.

The Upper Mississippi River 9-Foot Channel Project was one of the largest and most ambitious river improvement projects ever constructed in the United States. From conception to completion, the massive undertaking reflected the changing political moods of the nation, spanning several presidential administrations and agendas. The project originated in the 1920s when it was promoted as a way to alleviate the Nation's worsening farm crisis. It was also aimed at allaying the inequities in commercial rail and water freight rates brought about by the 1914 opening of the Panama Canal. Although direct governmental aid was an anathema to the conservative Warren Harding and Calvin Coolidge administrations, waterway improvements were an acceptable way to promote the general good. The 9-Foot Channel Project was authorized by the Rivers and Harbors Act of 1930 during the presidency of Herbert Hoover, an engineer and strong waterway improvements advocate. During the Great Depression, the project was recast into a massive public employment project by the New Deal administration of President Franklin Roosevelt. As a result, much of the 9-Foot Channel Project was constructed during what might be called the U.S. Army Corps of Engineers' "Golden Age," the period of its greatest dam construction, organizational security, highest volume of work, largest area of responsibility, and maximum power.

By the 1940s, the Corps of Engineers had successfully converted the once free-flowing river into a series of interconnected pools that ensured enough water for fully loaded modern boats and barges. The completion of the 9-Foot Channel Project turned the upper reaches of one of the world's largest rivers into an intra-continental channel, settling the question of a fully navigable, north-south, interior river system through the Midwest. The project brought economic benefits and recreational opportunities to the entire region. It also served as an impetus for the upgrading of municipal drinking water and sewage disposal systems in towns and cities located along the river.

But the project was not without controversy. Railroads, claiming damage to their right-of-ways, contested it in the courts. Conservationists feared its effects on the Upper Mississippi Valley environment. Indeed, the question of the lock and dam system's impact on the environment remains controversial even today. Ultimately, however, the economic benefits overrode all other concerns. From the beginning, the goal of increased commercial river transportation transcended all other considerations. After the project was completed, river traffic on the Upper Mississippi increased from 2,400,000 tons in 1939, to 68,400,000 in 1976. Business and politics had been well served.[2]

Now at least 50 years old, the locks and dams of the Upper Mississippi River 9-Foot Channel Project are showing their age. In their day, however, they represented technological breakthroughs in navigation engineering. The locks and dams that comprise the project constitute seminal developments in the technological history of American river navigation. With the 9-Foot Channel Project, the Corps of Engineers inaugurated a new era in slack-water navigation in the U.S.: the adoption of non-navigable dams that incorporated both roller and Tainter gates. Ironically, the Upper Mississippi River 9-Foot Channel Project also resulted in the obsolescence, by the project's end, of combination roller and Tainter gate dams. Technological advances resulting from the research and development incidental to the design and construction of the project's lock and dam systems enabled the U.S. Army Corps of Engineers to develop both submersible and non-submersible Tainter gates that nearly matched the capabilities of the roller gates, and which were less expensive and more easily operated. The Corps' creation of a new dam type, and its subsequent obsolescence during the course of a single project, dramatically illuminate the evolutionary nature of American engineering. Dam gates that were state-of-the-art at the beginning of the 9-Foot Channel Project were passe' before the project's end.

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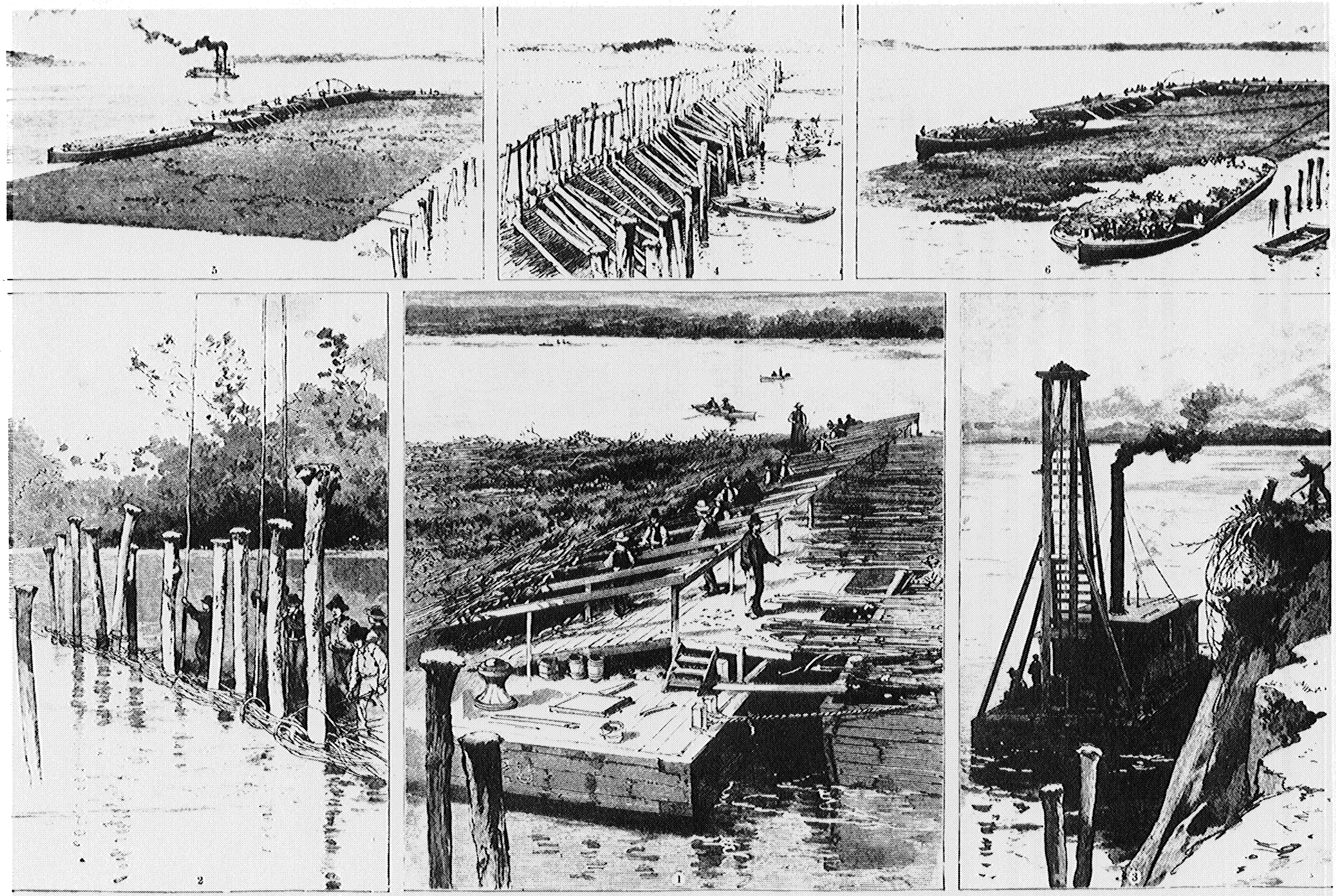


IMPROVEMENT OF THE MISSISSIPPI RIVER NEAR ST. LOUIS.—Drawn by Charles Graham from Photographs by Lieutenant Abbot.—[See Page 773.]

1. ~~Mattress~~-Weaving. 2. Wattling the Piles. 3. Caving Bank at Beard's Island. 4. Completed Hurdle Line. 5. Mattress 600 feet long ready to be sunk. 6. Stone Barges moving up-stream over Mattresses.

The Government began assuming responsibility for Upper Mississippi River navigation in the early nineteenth century. This illustration appeared in Harper's Weekly in 1884. Although materials and techniques became more advanced, the technology pictured here was still in use during the 9-foot canalization. During the 9-Foot Channel Project, woven timber mattresses, similar to those above, were placed around structure foundations to prevent scour. (State Historical Society of Missouri, Columbia)

CHAPTER I

Early Navigation on the Upper Mississippi River

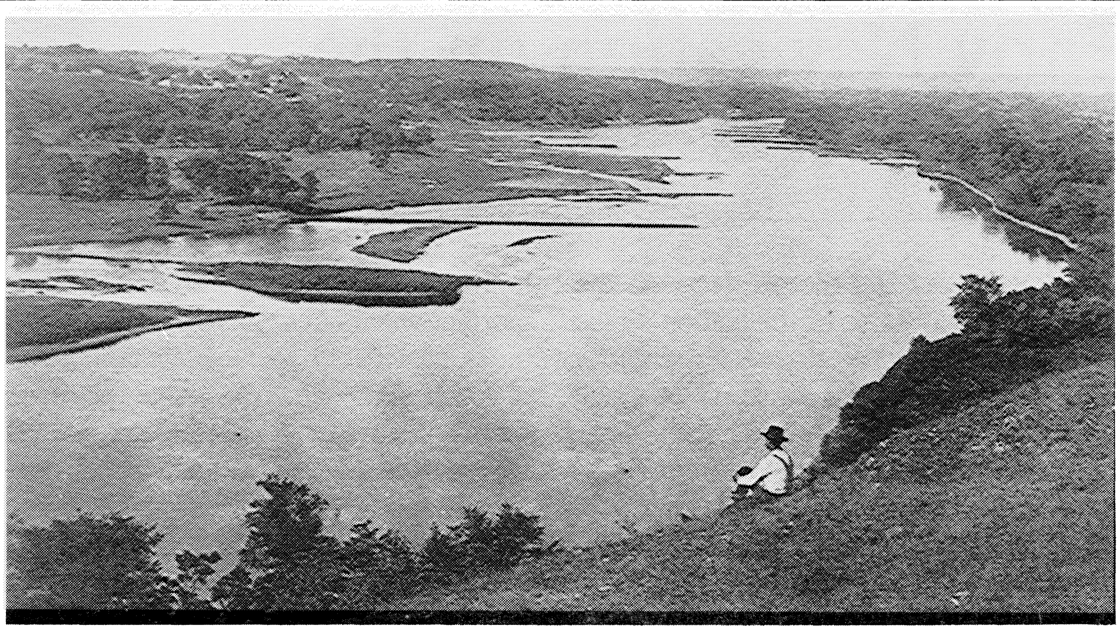
The 9-Foot Channel Project was the culmination of a 100-year effort to improve the navigability of one of the Nation's most important waterways, the Upper Mississippi River. Its navigational goal was straightforward: to provide a dependable channel depth on the river between St. Paul and St. Louis. Indeed, dependable, year-round, navigation on the Upper Mississippi had been a long-held dream of regional commercial interests. A major transportation route in the Upper Midwest, the river's navigational obstacles were, nevertheless, numerous.

The Upper Mississippi River begins as a stream near Lake Itasca in north-central Minnesota. From there, the Mississippi flows through the Upper Midwest for over 500 miles until reaching the St. Paul/Minneapolis area, where the stream becomes a navigable river. As the Upper Mississippi flows south from St. Paul to St. Louis, approximately 670 miles downstream, its banks help form the boundaries of five states: Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Along the way, the Upper Mississippi is fed by several streams including the Minnesota, St. Croix, Chippewa, Wisconsin, Rock, Des Moines, and Illinois Rivers. Just above St. Louis, the river joins with the Missouri River, gaining in strength and volume. Finally, approximately 170 miles south of St. Louis at Cairo, Illinois, the Mississippi River meets with the Ohio River, which more than doubles its volume. At this point, the Upper Mississippi becomes the Lower Mississippi, that "mile-wide tide, shining in the sun" made famous by Mark Twain.[1]

Prior to efforts to improve its navigability, the Upper Mississippi was a crooked and shallow river filled with shifting sand bars and shoals. The river's current could become dangerously swift and treacherous, particularly at places such as the Des Moines and Rock Island Rapids. The depth of the Upper Mississippi averaged approximately

3 feet and, at certain seasons, amounted to as little as 1 foot in the 200 miles below St. Paul.

Small, light, draft craft plied the Upper Mississippi for hundreds of years prior to the arrival of steamboating in the early nineteenth century. Native American cultures who had settled along the Mississippi as early as 900 A.D. utilized boats that were adaptable to the river's shallow depth and variable conditions. Canoes and pirogues, which were hollowed-out logs, could be either paddled or poled, depending on the depth of the water. Maneuverable and easy to portage, these boats were quickly adapted by the French for use in their explorations and fur trade.



Wing dams, the fingerlike extensions seen on both sides of the river in this historic photograph, constricted the river's flow, thereby speeding the current and providing a clear channel. From "Wingdams Below Ninninger, Minn., 1891," one of a series of photographs of the Mississippi River taken by H. Bosse, draughtsman with the Corps of Engineers, 1883-1891. (U.S. Army Corps of Engineers, St. Paul District)

The most sophisticated craft on the Upper Mississippi prior to the arrival of the steamboat was the keelboat, which began to be used sometime prior to 1800. These shallow-draft, flat-bottom vessels typically featured a covered cabin and, since they were pointed at both ends, had the advantage of being able to be poled or pulled upstream. Lieutenant Zebulon M. Pike and his men used a 70-foot keelboat during their exploration of the Upper Mississippi River Valley in 1805.

The first steamboat plied the Mississippi River below Cairo, Illinois, in 1811, but it was not until 1820 that Major Stephen H. Long in his Western Engineer--a specially-built, light draft, U.S. Army Corps of Engineers' survey and exploration boat--brought steamboating to the Upper Mississippi. Powered commerce came to the Upper Mississippi in 1823 with the arrival of the Virginia, a passenger and supply steamboat. With portages and canals to the Great Lakes, the Mississippi and its tributaries were the major transportation waterways by which the Upper Midwest was settled. Early railroad connections along the Upper Mississippi River enhanced its importance.[2]

Steamboat navigation on the Upper Mississippi, however, was impeded by the river's treacherous rapids. The Des Moines Rapids extended 11.25 miles upstream from the Des Moines River at Keokuk, Iowa, and consisted of a strata of hard rock. During low water stages, it was extremely difficult if not impossible to navigate this long stretch of shoal. The Rock Island Rapids extended 13.75 miles from the foot of Arsenal Island at Rock Island, Illinois, to Le Claire, Iowa. Here, chains of rock stretched out from each bank, and deep pools and channels of water twisted from shore to shore. Strong currents flowed around the chains and across the channels and pools.

The Federal Government began assuming responsibility for the elimination of troublesome spots in the river in the early nineteenth century. The Corps conducted a study of the Upper Mississippi in 1829, and concluded that it would be useable by steamboats 8 months a year if channels were blasted through the Des Moines and Rock Island Rapids. In 1837, Congress authorized the Corps to develop plans to improve Upper Mississippi River navigation. Lieutenant Robert E. Lee and Second Lieutenant Montgomery Meigs, acting as Lee's assistant, carried out this charge. In 1838 and 1839, Lee and a new assistant, Horace Bliss, supervised underwater blasting to create a 200-foot-wide and 5-foot-deep channel through the Des Moines Rapids. In 1854, the Corps also began deepening, widening, and straightening the main channel of the Rock Island Rapids. The Corps also dredged the river, removing snags and other hazards. Although neither the Des Moines nor Rock Island Rapids project were completed, the Corps ceased working on the river in 1856 and did not resume until after the Civil War.[3]

After the war, renewed Federal attention to waterway improvements initiated what would become a long series of attempts to channelize the Upper Mississippi. In 1866, the Federal Government appropriated $400,000 for a 4-foot-deep channel between Minneapolis and St. Louis. In June 1878, before the 4-foot channel project was complete, Congress authorized the Corps of Engineers to work towards the provision of a 4.5-foot depth. In 1907, Congress, under pressure from river improvement organizations who believed the 4.5-foot depth was inadequate, authorized the Corps to construct a 6-foot-deep channel from the mouth of the Missouri River to Minneapolis.[4]

Both the 4.5-foot channel and the 6-foot channel were to be achieved by a system of wing and closing dams, augmented by almost continual dredging. Wing dams constricted the flow of the river, speeding the current and providing a clear channel. Closing dams prevented the river from leaving the main channel and entering sloughs and side-channels. Both closing dams and wing dams were relatively simple structures, generally of brush or timber construction.[5]

But the 6-foot channel project, which was never fully completed, was outmoded almost from the moment of its authorization. A 9-foot channel was maintained on the Mississippi River below St. Louis. The discrepancy in channel depths meant that barge fleet operators ascending the Mississippi River either had to use smaller boats for the length of the Mississippi, or had to transfer cargo from larger to smaller boats in the Cairo/St. Louis vicinity before proceeding upstream. Either action cost time and money. Rather than reloading onto smaller craft at St. Louis, many barge fleet operators chose to ship their cargo by trains that could go to any location, landlocked or not. By the 1920s, other events--including a national farm crisis and the 1914 opening of the Panama Canal--had convinced many that a 6-foot-deep channel was inadequate.

CHAPTER ONE NOTES

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2.Ibid., 3, 6, 9-10.

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4.Hill, "Developing Upper Mississippi," 1352; Gross and McCormick, "Upper Mississippi River Project," 311; and Philip V. Scarpino, Great River: An Environmental History of the Upper Mississippi, 1890-1950 (Columbia: University of Missouri Press, 1985), 166-167.

5.P.S. Reinecke, "The Rhine and the Upper Mississippi," The Military Engineer 30 (May-June 1938): 168; and Philip V. Scarpino, Great River, the Upper Mississippi River Basin (Washington D.C.: Government Printing Office, 1984), 35.

CHAPTER II

The 1920s: Roots of the 9-Foot Channel Project

In the 1920s, farmers were the country's single, largest, social and economic group. The farm lobby constituted the most powerful and consistently successful group in Congress during the entire decade from 1919 to 1929. A significant percentage of America's farmers lived in the Upper Mississippi River drainage. Here, the river drains about 171,500 square miles in the States of Minnesota, Wisconsin, Iowa, Illinois, and Missouri. The economic condition of this vast domain--a region as large as the Nations of Germany, France, Italy, and Great Britain combined--depended primarily upon the prices obtained for food commodities, and the consequent buying power of its farmers.[1]

Between July 1920 and March 1922, agricultural prices plummeted throughout the Nation. The post-World War I revival of European agriculture and the development of new agricultural exporters such as Argentina and Australia cut domestic and foreign demand for American farm products. Simultaneously, American per-acre yields were increasing. As overproduction caused American farm prices to drop, farm expenses mounted. Although all the Nation's farmers suffered during this crisis, the farmers of the Upper Mississippi Valley fared worse than most.

Under the influence of their Secretary of Commerce, Herbert Hoover, both Presidents Warren Harding and Calvin Coolidge opposed direct aid to farmers. They believed a healthy economy needed free competition, and argued that direct aid to agriculture would eliminate competition among farmers. Instead, Congress attempted to aid farmers indirectly by regulating railroad rates, grain exchanges, commission merchants, and stockyards; exempting farm co-operatives from the anti-trust laws; easing agricultural borrowing; and approaching waterway improvement more systematically. Of these, Hoover most strongly supported waterway improvement.[2]

The Upper Mississippi Valley also looked towards waterway improvement as a remedy for its troubled economy, particularly after the 1914 opening of the Panama Canal. Constructed by the U.S. Army Corps of Engineers, the Panama Canal severely impacted commercial freight transportation costs in the Midwest. The Central American project placed the Midwest at a competitive disadvantage to the rest of the country by lowering intercoastal shipping rates below the railroad rates paid by Midwesterners. The Interstate Commerce Commission (ICC) compounded this disadvantage by raising railroad rates between St. Paul and St. Louis 100 percent. In the Indiana Rate Case of 1922, the ICC had stated that the Upper Mississippi River was only a potential waterway competition--not a functioning one--and ordered railroads along the river to raise their rates.[3]

Herbert Hoover summed up the prevailing situation in a 1926 speech when he stated that shipping rates affected by the opening of the canal had brought New York closer to San Francisco, while putting Chicago farther away from the Pacific Coast. "In other words," said Hoover, "Chicago has moved 336 cents away from the Pacific Coast while New York has moved 224 cents closer to the Pacific Coast." Hoover declared that this change in costs affected all of the Midwest. So long as full-season, commercial, through navigation remained impossible on the Upper Mississippi, the valley remained effectively landlocked.[4]

By this time, waterway improvement proponents had been arguing for over 50 years that a viable water route from the upper Midwest to the Gulf would reduce rail rates and provide additional cargo capacity. A navigable channel from St. Paul to St. Louis had long been the dream of Midwestern commercial interests who believed the Upper Mississippi River presented an opportunity to create a modern water link between the upper Midwest and New Orleans, a port offering excellent access to Central and South American export markets. Indeed, many leading 1920s international trade theorists saw the great undeveloped continent to the south much as their 1990s counterparts view the Pacific Rim and Eastern Europe, as the major hope for the future of the American export business.[5]

The first session of the 68th Congress, which convened in 1924, proved particularly momentous for all major waterways in the Midwest. An ad hoc commission headed by Herbert Hoover advocated the creation of a St. Lawrence River-based waterway linking the Great Lakes and the Atlantic Ocean. William E. Hull of Illinois introduced a bill to create a 9-foot channel from the Great Lakes to the Gulf of Mexico via the Chicago, Illinois, and Mississippi Rivers. And, of utmost importance for the Upper Mississippi River Valley, Congressman Cleveland A. Newton of Missouri introduced a bill calling for the completion within 5 years of all the already authorized improvement projects for the Mississippi system's major northern components.[6]

Newton hoped to ensure a dependable channel for navigation north of Cairo, Illinois. Specifically, Newton's bill called for the Corps of Engineers to complete, by 1929, four previously-authorized but still-incompleted projects: (1) a 9-foot channel in the Ohio River from Pittsburgh to Cairo as authorized in 1910; (2) a 6-foot channel in the Missouri River between Kansas City and the Upper Mississippi River as also authorized in 1910; (3) a 9-foot channel in the Upper Mississippi from Cairo to the Illinois River, an amalgamation and updating of an 8-foot project and a 6-foot project both authorized in 1910; and (4) a 6-foot channel in the Upper Mississippi River from Minneapolis to the mouth of the Missouri River, located just above St. Louis, as authorized in 1907. Congress had originally mandated a 1922 deadline for the completion of the 6-foot channel. By the end of that year, however, the 15-year-old project remained less than half complete.[7]

Although Congressman Newton failed to raise the issue of increasing the Upper Mississippi River channel to a 9-foot depth, that concept was introduced into the hearings on the Newton bill by Halleck W. Seaman. Seaman, a railroad magnate from Clinton, Iowa, testified that he "did not know what is the matter with my friend Cleveland Newton that he did not make it 9 feet, as it is down below." Like other Upper Mississippi River boosters, Seaman wanted the Upper Mississippi to be the same depth as the river's main trunk. When the Chairman of the House Rivers and Harbors Committee, S. Wallace Dempsey of New York, pointed out that a 9-foot depth would require a study, which would delay rather than accelerate progress, Seaman withdrew his suggestion. He was confident that the impracticality of a 6-foot channel would eventually force the Corps of Engineers to build a 9-foot channel, whether it wanted to or not. Seaman would soon be proved correct. In 1926, the government-owned Inland Waterways Corporation began operating barges on the Upper Mississippi. The government's experiences, together with those of other barge operators, reinforced impressions concerning the inadequacy of a 6-foot channel on the Upper Mississippi.[8]

Meanwhile, other developments were leading towards the construction of a 9-foot-deep channel on the Upper Mississippi. In February 1925, the new U.S. Army Corps Chief of Engineers, Major General Harry Taylor, questioned how best to secure a 6-foot channel on a stretch of the Upper Mississippi River between St. Paul and the Chippewa River. Taylor believed that blasting and dredging the channel was improbable, so he asked the Rivers and Harbors Committee to authorize a re-examination and survey of this section of the river with a view towards the construction of a slack-water navigation system. The 1925 Rivers and Harbors Act, which authorized the Newton Bill, also authorized this survey. In December 1926, the Corps recommended that the best way to secure a 6-foot channel in that section of the river would be through the construction of a lock and dam at Hastings, Minnesota.[9]

Once the Corps admitted the need for a lock and dam to achieve a 6-foot channel at Hastings, it appeared the engineers had to admit the necessity of slack-water navigation elsewhere on the Upper Mississippi. At times, there was as little as 4.3 feet of water in the 2.5 mile stretch of river above the Rock Island Rapids. To solve this problem, the Corps either had to build a lock and dam at that site or blast a very deep, wide, and expensive channel through 2.5 miles of rock. The prospect of several new lock and dam complexes at various intervals along the river encouraged consideration of a 9-foot channel. If a series of locks and dams were to be constructed, why not make them a little bigger in order to create a significantly more useful waterway?

On April 26, 1926, in a hearing before the House Committee on Rivers and Harbors, Chairman S. Wallace Dempsey, together with Congressmen William W. Chalmers of Ohio, pressed Chief of Engineers Taylor hard on the implications of a lock and dam at Hastings, Minnesota. They forced the General to admit that it *would* be possible to build enough locks and dams to give the Upper Mississippi a 9-foot-deep channel. General Taylor refused, however, to say if this could be done at a cost commensurate with the resultant increase in freight. Nevertheless, in January 1927, Congress authorized the Corps to build a lock and dam at Hastings and to "examine the Upper Mississippi River with a view to securing a channel depth of 9 feet at low water with suitable widths."[10]

CHAPTER TWO NOTES

1.Arthur S. Link, "What Happened to the Progressive Movement in the 1920s?," American Historical Review 64 (1959), as reprinted in David M. Kennedy, ed., Progressivism: The Critical Issues (Boston: Little, Brown, and Company, 1971), 158-159; U.S. Congress, House, Mississippi River, Between Mouth of Missouri River and Minneapolis, Minnesota (Interim Report), H. Doc. 290, 71st Cong., 2nd sess., 1930 (hereafter referred to as H. Doc 290); U.S. Congress, House, Hearings before the Committee on Rivers and Harbors, House of Representatives, 73rd Congress, 1st Session, on the Subject of Continuing the Improvement of the Upper Mississippi River, and Proposals of the American Railways in Connection with the Improvement of Inland Waterways, Distribution of Expenses for Reconstruction of Bridges and Other Structures, Proposed Tonnage Tax or Toll Charge, May 2-5, 1933 (hereafter referred to as Hearings, May 1933), 59; Theodore Saloutos and John D. Hicks, Agricultural Discontent in the Middle West, 1900-1939 (Madison: University of Wisconsin Press, 1951); and Russell B. Nye, Midwestern Progressive Politics (New York: Harper and Row, 1959).

2.The fact that these administrations were opposed to direct farm aid does not mean that the idea did not have strong adherents. It was a resident of the Upper Mississippi Valley, George N. Peek, a plow manufacturer from Moline, IL, who in 1921 advanced the most famous scheme for direct Federal aid to farmers. Peek proposed that the Federal government buy up surplus American agricultural products. In "Equity for Agriculture," Peek suggested that the Federal government buy American farmers' surplus wheat. The 1927 McNary-Haugen Bill, which Coolidge vetoed only to have Congress pass again in 1928 and Coolidge veto again, was a variant of Peek's plan. See Gilbert C. Fite, George N. Peek and the Fight for Farm Parity (Norman: University of Oklahoma Press, 1954), passim.

3.John O. Anfinson, "Upper Mississippi River, Nine-Foot Channel History, Part 1: Why Congress Authorized the Project" (St. Paul: U.S. Army Corps of Engineers, St. Paul District, draft copy, October 1990), Chapter 3: 12.

4.Patrick James Burnet, "The Corps of Engineers and Navigation Improvements on the Channel of Upper Mississippi River to 1939" (Master's Thesis, University of Texas at Austin, 1977), 88.

5.U.S. Congress, House, Committee on Rivers and Harbors, Hearings on H.R. 3921 providing for the Improvement and Completion of Prescribed Sections of the Mississippi, Missouri, and Ohio Rivers held before the Committee on Rivers and Harbors, 68th Congress, 1st session, March 20-24 and April 4, 1924 (hereafter referred to as Hearings 3921), 101-102; U.S. Congress, House, Committee on Rivers and Harbors, Statement of Hon. Herbert Hoover, Secretary of Commerce, before the Committee on Rivers and Harbors, House of Representatives, 69th Congress, 1st session, on the subject of the Development of Inland Waterway Systems in the United States, January 30, 1926, 15; U.S. Congress, House, Committee on Rivers and Harbors, Hearings before the Committee on Rivers and Harbors, House of Representatives, 72nd Congress, 1st session, on the subject of "The Improvement of the Mississippi River between the mouth of the Missouri River and Minneapolis," January 25-27, 1932 (hereafter cited as Hearings, January 1932) 40-41; and William J. Hull and Robert W. Hull, The Origin of the Waterways Policy of the United States (Washington D.C.: National Waterways Conference, 1967), 31-37.

6.U.S. Congress, House, A Bill Providing for the Improvement and Completion of Prescribed Sections of the Mississippi, Missouri, and Ohio Rivers, H.R. 3921, 68th Cong., 1st sess., 1924.

7.Hearings 3921, 1-3, 24.

8.Ibid., 90-94. An influential force in the American transportation industry, Halleck W. Seaman was so well known that he required no introduction to the members of the House Rivers and Harbors Committee. By 1911, Seaman, a lawyer and a civil engineer, was simultaneously president of six railroad companies and director and syndicate manager for another. He was also a member of the executive committee of the Mississippi Valley Association, the Upper Mississippi Waterways Association of Minneapolis, and the Inland Waterways Corporation. P.B. Wolfe, Wolfe's History of Clinton County, Iowa (Indianapolis: B.F. Bowen & Co., 1911), 2:1092-1094; Citizens Historical Association, "H.W. Seaman, Attorney, Clinton Wire Cloth Company, 509 Weston Building, Clinton, Iowa," entry no. 2D13E23F1JHA/CFD, November 11, 1939, copy in Clinton Public Library; "Halleck Seaman, Man of Vision," Clinton Herald, Centennial Edition, June 18, 1955; and History of Clinton County Iowa (Clinton: Clinton County Historical Society, 1976), 173-174.

During World War I, the railroads' inability to handle intra-continental freight was so great that the Federal government began operating barge and towboat fleets in order to re-establish waterway commerce. After the war, much of this fleet was transferred to the War Department which continued to offer barge service through its Inland and Coastwise Waterways Service which, in 1924, became the Inland Waterways Corporation. Hill, "Developing Upper Mississippi," 1352; Raymond H. Merritt, The Corps, the Environment and the Upper Mississippi Basin (Washington D.C.: U.S. Army Corps of Engineers, Historical Division, Office of Administrative Services, Government Printing Office, 1984), 53; Jon Gjerde, "Historical Resources Evaluation: St. Paul District Locks and Dams on the Mississippi River and Two Structures at St. Anthony's Falls" (St. Paul: U.S. Army Corps of Engineers, St. Paul District, 1983), 89-92; Proceedings of the Twenty-Second Convention National Rivers and Harbors Congress, Washington, D.C., December 8 and 9, 1926 (Washington D.C.: Press of Randall Inc, 1927), 31-33; Marshall E. Dimock, Developing America's Waterways: Administration of the Inland Waterways Corporation (Chicago: University of Chicago Press, 1935), passim; and Michael C. Robinson, "The Federal Barge Fleet: An Analysis of the Inland Waterways Corporation, 1924-1939," National Waterways Roundtable Proceedings (Washington, D.C.: U.S. Government Printing Office, 1980), 107-125.

9.U.S. Congress, Senate, Report on the Proposed River and Harbor Bill (H.R. 11472) S. Rpt. 1143, 68th Cong., 2nd sess., February 17, 1925, 15; and Rivers and Harbors Act of March 3, 1925, 1195.

10.U.S. Congress, House, Survey of Mississippi River Between the Mouth of the Missouri River and Minneapolis, H. Doc. 137, 72nd Cong., 1st sess., 1932 (Hereafter referred to as H. Doc 137, this report is a seminal document in the study of the Nine-Foot Channel); Mississippi River Lock and Dam No. 15: Final Report Construction, Vol. I: Text (Rock Island: U.S. Engineer Office, Feb. 1935), 48, RG77, entry 81, box 668, National Archives and Records Center, Chicago (hereafter referred to as NACB); U.S. Congress, House, Hearings Before the Committee on Rivers and Harbors, House of Representatives, 69th Congress, 1st session, April 26, 1926, 188; and Rivers and Harbors Act of January 21, 1927, 69th Cong., 2nd sess., chapter 47.

Charles Hall. (U.S. Army Corps of Engineers, Rock Island District)

CHAPTER III

Opposition to the Channel

With the passage of the Newton Bill in 1925, it was clear that the Federal Government was committed to deepening the channel in the Upper Mississippi River. But the depth of that channel, whether it should be 6 feet or 9 feet, remained controversial. And, surprisingly, much of the controversy came from within the Corps of Engineers itself.

In 1927, when Congress ordered the Corps to study the feasibility of a 9-foot channel on the Upper Mississippi, the job was given to Major Charles L. Hall. At the time, Hall was in the second year of a 3-year tour of duty in the Chief of Engineers' office in Washington, D.C. A 1908 West Point graduate, Hall was just turning 40 and had spent almost half his life serving in the Corps. An experienced officer who understood the political realities of military decision-making, Hall had served with the punitive expedition into Mexico, and the American Expeditionary forces during World War I. In 1920, he was assigned to the Chief of Engineers' office. From 1924 to 1926, he served as a member of the War Department general staff and, in 1926, returned to the Chief of Engineers' office. In 1927, the Corps cut short Hall's tour of duty in Washington and assigned him District Engineer of the Rock Island District, where he was to undertake the 9-foot channel feasibility study.[1]

To the horror of local politicians and business interests, Major Hall recommended against the 9-foot canalization. In August 1928, Hall submitted a preliminary report to his superiors in which he opposed the project. In a second report dated February 1929, Hall argued that the existing, government-subsidized, limited barge traffic on the Upper Mississippi did not indicate that a viable barge industry would develop even if a 9-foot channel were created. Hall believed the project was economically inadvisable. Moreover, Hall concluded that the project would have disastrous environmental impacts.[2]

Hall knew that the only feasible way to provide a 9-foot depth on the Upper Mississippi was through a series of locks and dams that would transform the river from a free-flowing stream into a series of interconnected lakes. Echoing the concerns of

Midwestern conservationists, Hall feared that these slack-water pools would create vast swamps of stagnant and polluted water. He was also concerned about the effect of slack-water navigation on indigenous wildlife. In an address to the School of Wildlife Protection in McGregor, Iowa, Major Hall stated that the project would "radically change" the wildlife of the region. The outcry was immediate and furious. An editorial in the Minneapolis Journal berated Hall, stating that the Major's duties were "neither floral or faunal, but engineering," and suggested that his time might be better spent in areas in which he had been specifically trained.[3]

Hall's comments, though, reflected a growing national environmental awareness. Fostered by the work of Mississippi Valley native Aldo Leopold and other conservationists, several environmental groups were reevaluating lock and dam projects and their effects on river valley environments. Controversy over projects such as the Hetch Hetchy Dam near San Francisco (1907-1913) and the Keokuk Power Plant and Dam (1910-1913) prompted those concerned with the Upper Mississippi Valley environment such as Will Dilg, founder of the Izaak Walton League of America, to actively oppose the canalization project.

Previous environmental concerns on the Upper Mississippi had surfaced in 1923, when a proposal was made to drain approximately 30,000 acres of the Winneshiek Bottoms, a 30-mile area on the Wisconsin side of the river. The ensuing battle between conservationists and developers resulted in a victory for the conservationists, and the establishment of the Upper Mississippi Wildlife Refuge. Now, 6 years later, questions centered around flooding instead of drainage. The proposed 9-foot channel's lock and dam system would create permanent, large-scale, flooding of formerly non-inundated and seasonally inundated lands along the Upper Mississippi, appreciably affecting the ecology of the area.

Hall's report also drew angry criticism from politicians who saw the project in an entirely different light. They believed that the limited navigation on the Upper Mississippi River was a justification for the 9-Foot Channel Project, not grounds on which to oppose it. The 9-foot channel would increase navigation, the politicians argued, thus providing its own economic justification. Although Congress had directed the Corps of Engineers to evaluate the economic benefits of the 9-Foot Channel Project, some politicians felt that Hall had overstepped his bounds. They believed it was up to the Corps of Engineers to build the 9-foot channel, not justify it on economic and environmental grounds.

Key members of the Corps were also unhappy with Hall's report. Therefore, it is not surprising that, although not "convinced of the advisability of the improvement," Hall recommended an additional survey to determine the cost of providing a dependable 9-foot-deep channel, 200 feet wide in the straight reaches, and at least 300 feet wide at bends, between the mouth of the Illinois River and Minneapolis. Although Major Hall initially served on the six-member survey team that conducted this "more thorough" survey, he was removed from that position before the final report was submitted.

Hall's role in the 9-foot channel controversy did not help his career. Although at the beginning of the 9-Foot Channel Project, Hall was District Engineer of the Rock Island District, he was replaced by Major Glen E. Edgerton in December 1930. After leaving the Rock Island District, Hall taught at West Point. From 1932 to 1936, he served as the Cincinnati District Engineer. In 1941, Hall returned to Cincinnati where he served as Ohio River Division Engineer, a position he held until 1945 when he retired from the Corps with the rank of Colonel.[4]

Major Hall may have been a victim of political storms beyond his control. What upriver business interests saw as recalcitrance was, in reality, a direct reflection of Corps policy. In his 1926 appearance before the Committee on Rivers and Harbors, Corps Chief of Engineers Taylor had only begrudgingly admitted the *technical* possibility of a 9-foot channel, but refused to concede its economic advisability. Taylor's successor, Major General Edwin Jadwin, also opposed the project.

Jadwin shared Hall's environmental concerns, and was concerned about the project's flood control problems. In addition, Jadwin, like other Progressive Era thinkers, believed that projects should stand on their own merit and not be the product of special interest politics, no matter how powerful. But such attitudes refused to recognize the political realities attendant in the 9-Foot Channel Project. Many politicians felt the progressive line of thought was arrogant. Jadwin's acknowledgment that movable dam systems constituted the only logical way to assure a 9-foot channel--and his concurrent refusal to endorse the project--looked to some as being not only contradictory, but downright haughty. During the controversy over Hall's report, Jadwin stood on a middle ground. Not surprisingly, the results of the second survey favored the 9-foot canalization. Jadwin's actions reflect a man caught in a political bind. Following the election of Herbert Hoover in November 1928, Chief of Engineers Edwin Jadwin was replaced by Major General Lytle Brown. Ten senior officers were passed over to assure Brown, who supported the 9-foot Channel Project, of his appointment.[5]

On December 29, 1929, Chief of Engineers Brown departed from ordinary practice by releasing an advance report of the still incompleted 9-Foot Channel Project survey. He later claimed that he only did this "on the urgent request of interested parties." The official advance report, published on February 15, 1930, as House Document 290, affirmed that the special Board of Engineers, the Corps Board of Engineers for Rivers and Harbors (BERH), and the Chief of Engineers all agreed that a 6-foot channel depth on the Upper Mississippi was "self-limiting" and not adequate to build up a commerce that would justify the necessary expenditures. The report recommended that the 6-foot project authorization on the Upper Mississippi be modified at once so all further permanent work be built in such a way that it could be enlarged in accord with a 9-foot channel project.[6]

But project boosters were dismayed to learn that the Corps of Engineers did not support the immediate authorization of the 9-foot channel. Although the Corps' survey favored a 9-foot depth, the Corps recommended that full authorization of such a project be delayed until yet another, more detailed study was completed. Promoters of the 9-foot channel feared that such a delay would effectively kill the project.

Turning to the President for recourse, project supporters were shocked to discover that Hoover, a long-time waterway improvements advocate, also opposed immediate authorization. With the Nation in the throes of a depression, Hoover found it difficult to justify such an expensive navigation improvement project. Hoover supported the project, but wanted to delay its funding until the financial condition of the country improved.[7]

Upper Mississippi River interests were unwilling to wait. On April 25, 1930, the House passed a Rivers and Harbors Act that did not include authorization of the 9-foot channel. As hopes for the project faded, supporters turned to the Senate for help. Senator Henrik Shipstead of Minnesota quickly proposed an amendment that added the 9-Foot Channel Project to the Rivers and Harbors Act. By the end of May 1930, the Senate Commerce Committee had voted in favor of the Shipstead Amendment. On June 16, 1930, the amended Rivers and Harbors Act was passed by the full Senate. By the end of June, the House had also accepted the amended bill. On July 3, 1930, the 9-foot channel legislation was signed into effect by President Herbert Hoover.[8]

Despite all setbacks, the 9-Foot Channel Project's authorization had preceded its final survey report and project plan by over a year and a half, a phenomenon virtually unheard of for Corps waterway projects. The 1930 Rivers and Harbors Act ordered the existing Upper Mississippi River 6-foot channelization be "modified so as to provide a channel depth of 9 feet at low water with widths suitable for long-haul common-carrier service." It also appropriated an initial expenditure of $7,500,000 for the 9-foot canalization.[9]

In December 1930, the special Board of Engineers delivered its final survey report to the Chief of Engineers. Submitted to Congress in December 1931, the report was published in January 1932 as House Document 137. Concluding that slack-water navigation provided the most economical and dependable means for securing a 9-foot channel, the report called for the construction of 24 new locks and dams below Hastings, Minnesota, and the incorporation of 3 existing structures into the project. (Only 23 lock and dam installations were built; Lock and Dam No. 23 was later eliminated from the plan. The existing locks and dams were Nos. 1, 2, and 19.) The estimated cost of channelizing the Upper Mississippi was $124,006,139. Annual maintenance and operating costs were estimated to be $1,750,000.[10]

Estimated Cost of the 9-Foot Channel Project

The final survey report of the 9-Foot Channel Project, published in January 1932 as House Document 137, included the following cost estimates:

Purchase of three large modern dredges		$ 1,500,000
Additional survey and studies		600,000
Dredging, Washington Avenue Bridge to Northern Pacific Bridge		356,000
Dredging, pool 1, below Washington Avenue Bridge		94,000
Second lock, Twin Cities Lock and Dam		1,300,000
Dredging, head of Hastings pool		290,000
Second lock at Hastings		1,500,000
Lock and Dam No.--	3	3,502,487
	4	3,910,821
	5	3,921,413
	5A	3,863,772
	6	3,017,063
	7	4,445,934
	8	4,551,613
	9	4,158,294
	10	3,721,800
	11	3,775,850
	12	3,673,800
	13	4,165,400
	14	3,437,300
	15 (Rock Island--including flowage damage and removal of old lock)	6,416,000
	16	4,889,100
	17	4,381,400
	18	5,456,400
	Dredging at head of pool 19, including removal of standing timber	33,000
	Second lock at No. 19, Keokuk	1,500,000
	20	4,850,500
	21	4,837,600
	22	4,583,000
	23	4,842,500
	24	5,179,200
	25	4,050,500
	26	4,577,600
Removal of Wing Dams		228,700
Flowage Damages		12,395,092
Total Estimated Cost		**$124,006,139**

Estimated annual operating and maintenance costs:	
Operation and care of locks and dams	$ 750,000
Channel stabilization and maintenance	$ 1,000,000
Total Annual Cost	**$ 1,750,000**

CHAPTER THREE NOTES

1.Tweet, Rock Island District, 378.

2.Major Robert C. Williams, St. Paul District Engineer, to C.C. Webber, August 16, 1928, as cited in Anfinson, Chapter 5: 13; and Raymond H. Merritt, Creativity, Conflict and Controversy: A History of the St. Paul District U.S. Army Corps of Engineers (St. Paul: U.S. Army Corps of Engineers, St. Paul District, 1980), 187-214.

3.Ibid.; and Burnet, "Navigation Improvement to 1939," 96-97.

4.The special Board of Engineers that conducted this survey beginning on May 29, 1929, was comprised of Major Hall; Lieutenant Colonel George R. Spalding, Louisville District Engineer; Lieutenant Colonel Wildurr Willing, St. Paul District Engineer; Major John Gotwals, St. Louis District Engineer; and Brigadier General Thomas H. Jackson, Western Division Engineer. H. Doc. 290, 7; Hearings, January 1932, 4; Tweet, Rock Island District, 378; and Leland Johnson to Christine Whitacre, April 19, 1991, files of the National Park Service, Rocky Mountain Regional Office, Lakewood, Colorado.

5.Burnet, "Navigation Improvement to 1939," 96-97; Mary Yeater Rathbun, "The United States Army Corps of Engineers in the Little Rock District," Rock Island: U.S. Army Corps of Engineers, Rock Island District, 1987 (draft), Chapter IV, "A New Attitude Towards Water Resources 1898-1921," 121, and Chapter V, "Origins of the Reactivated District 1921-1937," 170.

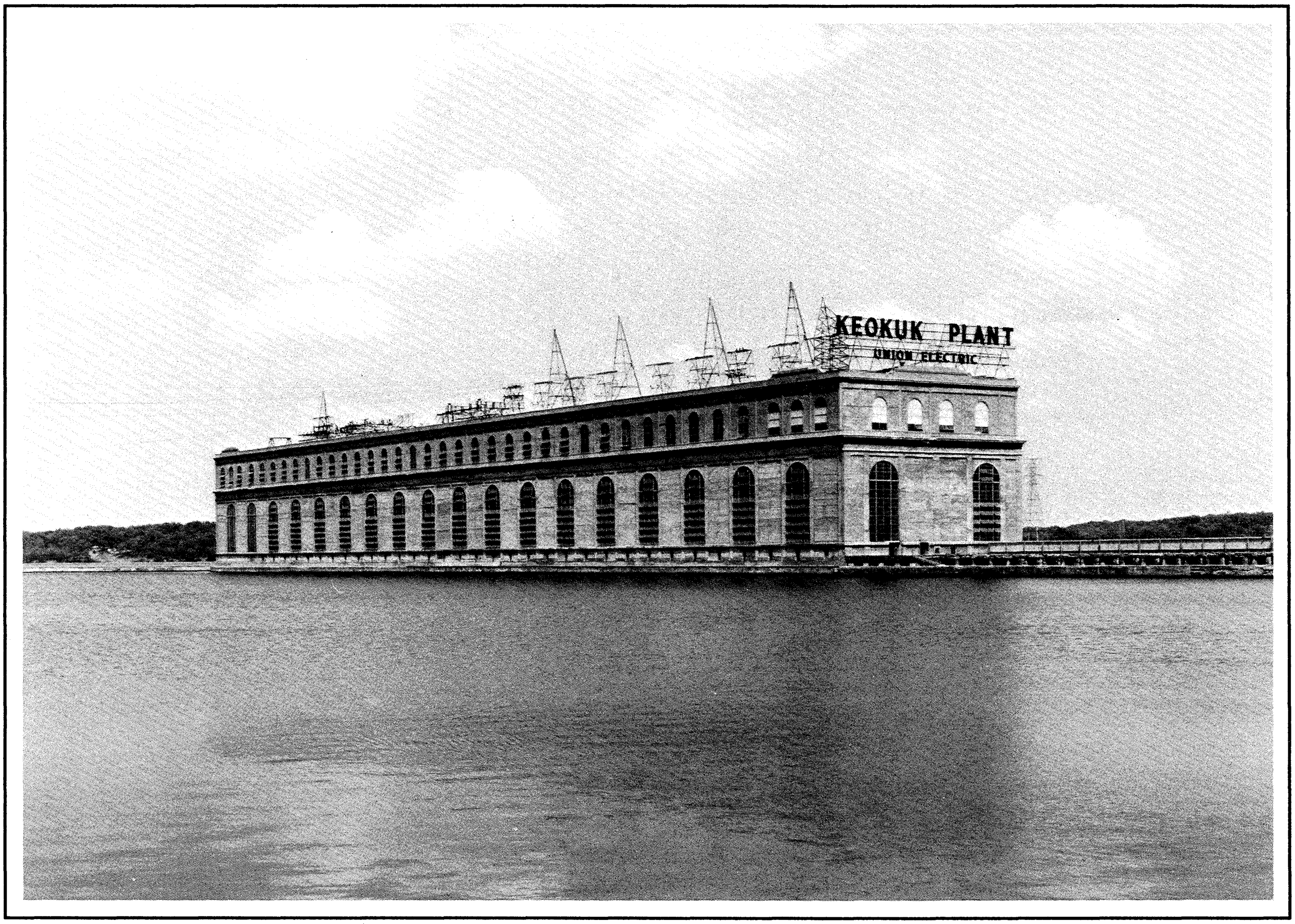
6.H. Doc. 290, 1-8, 37, 49; Hearings, January 1932, 36; and H. Doc. 137. Congress created the Board of Engineers for Rivers and Harbors (BERH) within the Corps in 1902 to review all prospective Corps projects independent of any local political influence. In theory, BERH only recommends projects which the standing board members from throughout the country, acting as professional engineers and not administrators, judge meritorious for construction.

7.Anfinson, Chapter 5: 29-30.

8.Ibid., 37.

9.July 3, 1930, Rivers and Harbors Act, 71st Congress, 2nd sess., Chapter 847.

10.H. Doc. 137, 1-10.



The Keokuk and Hamilton Power Plant established the precedent for non-navigable structures on the Upper Mississippi River. Completed in 1914, the dam for the hydroelectric project is located in the heart of the navigable section of the river. (Peter A. Rathbun)

CHAPTER IV

Building a Slack-Water System on the Upper Mississippi

At the time of the 9-Foot Channel Project authorization, slack-water navigation systems were not new. But, with the Upper Mississippi River 9-Foot Channel Project, the Corps of Engineers created a slack-water system that used *non-navigable* dams. And, as with so many other elements of the 9-Foot Channel Project, the decision to use non-navigable dams on one of the nation's most important waterways was controversial.

As its name implies, a slack-water navigation system is comprised of a series of "still water" pools, created by a series of dams across the river. The pools are connected by navigation locks. French and American engineers had begun building slack-water navigation systems in rivers in the 1830s. U.S. Army engineers began studying such river improvements in the 1840s. The Corps of Engineers' first bank-to-bank structure was the Davis Island Lock and Dam on the Ohio River. The Corps designed the Davis Island Lock and Dam between 1874 and 1878. When it was completed in 1885, the Davis Island Lock and Dam initiated what became, until the Upper Mississippi River 9-Foot Channel Project, traditional American practice for slack-water navigation.

Corps engineers designed the Davis Island Dam as a masonry sill set into the riverbed. Superimposed on the sill were Chanoine "wickets" or gates. When the water level on the Ohio River was low, river traffic had to pass through a lock to get across the Davis Island Dam. However, during the relatively long high-water stages on the Ohio River, some of the dam's wickets were laid flat across the sill, permitting river traffic to pass directly over the dam. Because the wicket gates of the Davis Island Dam could be moved, the dam was considered "movable." Because river traffic could pass over the Davis Island Dam rather than having to go through the lock, the dam was "navigable." In a non-navigable dam, all river traffic must pass through the lock, regardless of how high the river's flow.

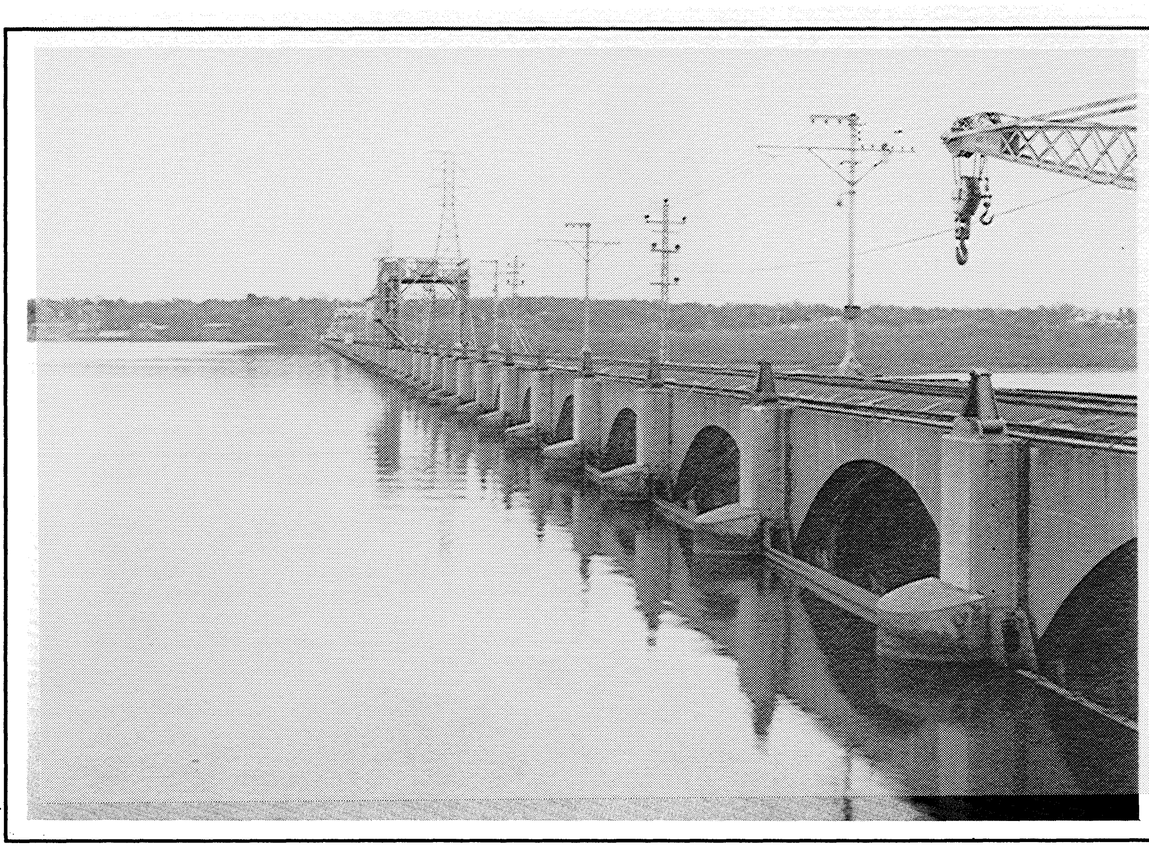
A movable dam was the key to successful slack-water navigation. Although movable dams have existed in primitive forms since ancient times, the modern movable dam is usually traced to a series of improvements that began in 1832 when Thenard, an officer in the French Corps of Engineers, devised a system for raising panels in a dam through the use of chains attached to a winch. Early American movable dams drew on native innovations, such as the bear trap dam gate invented by Josiah White in 1818 for use on the Lehigh River. However, because they did not include locks, these early experiments with movable dams did not produce slack-water navigation systems as they are defined today. Traffic either passed directly over the dams or through gates in the dams. American slack-water navigation systems that included locks as well as dams were located on Ohio's Muskingum River as early as 1832, and on Kentucky's Green River in 1833.[1]

Rivermen and engineers preferred navigable dams for a variety of reasons. Foremost among them were the types of vessels that navigated America's rivers. On both the Ohio and Upper Mississippi Rivers, barges were a major form of transportation. Developed by western rivermen after the Civil War, the barge system was seen as a high volume method of competing with the railroads. After 1866, coal shippers used the barge system extensively in the Ohio River Valley and its tributary region. The lead mining companies of the Upper Mississippi River Valley also used the barge system, and it was not long before grain haulers began using barges to haul bulk agricultural products out of the region. Fleets of 8 to 20 barges, bound to a steam towboat by a complex system of cables and chains, were a common sight on the Upper Mississippi after 1870.[2]

The Upper Midwestern lumber industry also depended on open river navigation. From 1870 until about 1905, logs were a major commodity transported on the Upper Mississippi River. The lumber companies floated many of the logs harvested in the forests of Wisconsin and Minnesota down the Upper Mississippi to markets and saw mills as far south as St. Louis. Between 1875 and 1900, more than 100 special steamboats--called raftboats because they pushed massive log rafts downriver--traveled the Upper Mississippi. While a typical steamboat rarely exceeded 100 by 300 feet, a raftboat and its log tow often measured 300 feet wide and 1,500 feet long. Raftboats and their tows needed a wide, open river. Because the tows would have had to be broken up and reassembled repeatedly, neither barge/towboat units nor raftboats could be operated economically in a lock-bound, non-navigable dam system.[3]

Packet boat operators were also opposed to non-navigable dams. Packet boats carried passengers, mail, and valuable or special freight. Competing with the railroads, packet boats operated on tight schedules. On the Upper Mississippi River, it would have taken approximately 40 hours for a fleet of barges to pass through a lockage, while a packet boat needed only an hour or less. Still, in their stiff competition with the railroads, that hour was just as critical for the packets as the 40 hours were to the barges.

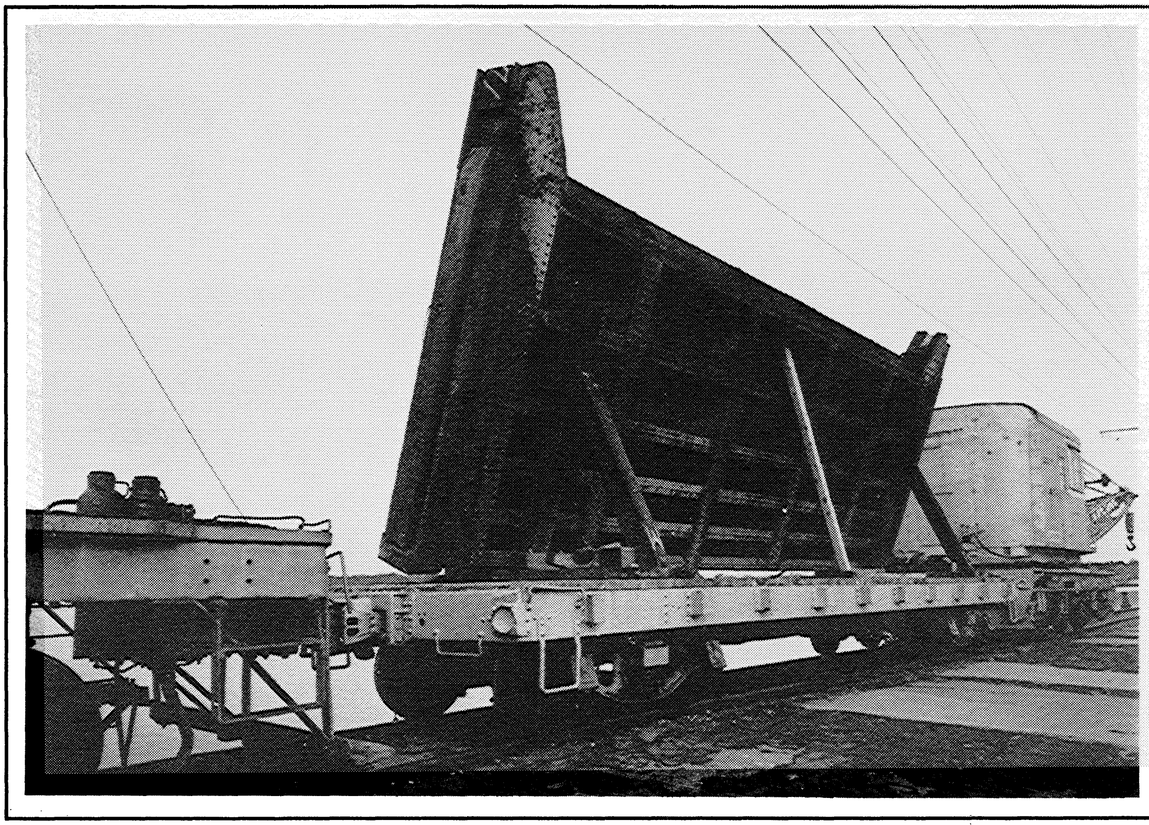
Prior to the 9-Foot Channel Project, virtually all of the navigation improvements on the Upper Mississippi provided for open river navigation. In 1882, the Corps began building a series of dams on the headwaters to help improve the navigability of the Upper Mississippi. These dams created pools whose waters were released to supplement the natural flow of the river south of Minneapolis during periods of low water. Because the dams were not located in navigable reaches of the river, they were in accord with the idea of keeping the navigational areas of the river as free from obstructions as possible.[4]



The Keokuk dam, which is privately owned, has 119 rectangular sliding gates, located between 120 piers on 36-foot centers. (Peter A. Rathbun)

The Corps' commitment to open water navigation was also acknowledged in 1894 when the Corps began building the first two locks and dams spanning the Upper Mississippi. These two locks and dams did not impair open water navigation anywhere that such navigation was already being practiced. Both of these structures were between St. Paul and Minneapolis, that is, at the head of navigation. Thus, they impaired very little traffic and, in fact, opened a whole new stretch of the river to any kind of substantial navigation for the first time.[5]

In 1903, Montgomery Meigs, a civilian employee with the Corps' Rock Island District, broke with this pattern of building only navigable structures on the Mississippi River. Meigs, whose father had assisted Robert E. Lee in the 1837 study of the Upper Mississippi River, endorsed a plan to build a bank-to-bank structure at the foot of the Des Moines Rapids. Conceived by the Keokuk and Hamilton Water Power Company, this plan called for the construction of a non-navigable dam in the very heart of the navigable section of the river.[6]



Keokuk Dam Gate. Movable cranes are used to slide the individual dam gates into place. (Peter A. Rathbun)

The Keokuk and Hamilton Water Power Project was the result of an idea that had been germinating since at least 1836: exploiting the water power available at the foot of the Des Moines Rapids. By the 1880s, the concept of multipurpose water resource development had gathered support throughout the country. Leaders of the emerging progressive and conservation movements had fostered an awareness that America's waterways should be developed not only to aid navigation, but also to control floods, irrigate crops, generate hydroelectric power, and provide water for municipal and industrial use. Simultaneously, navigation faced a crisis. The 1890s marked the victory of rail over water-borne transportation for long-distance hauls. In ever increasing numbers, water transport boosters jumped on the multiple-use bandwagon.[7]

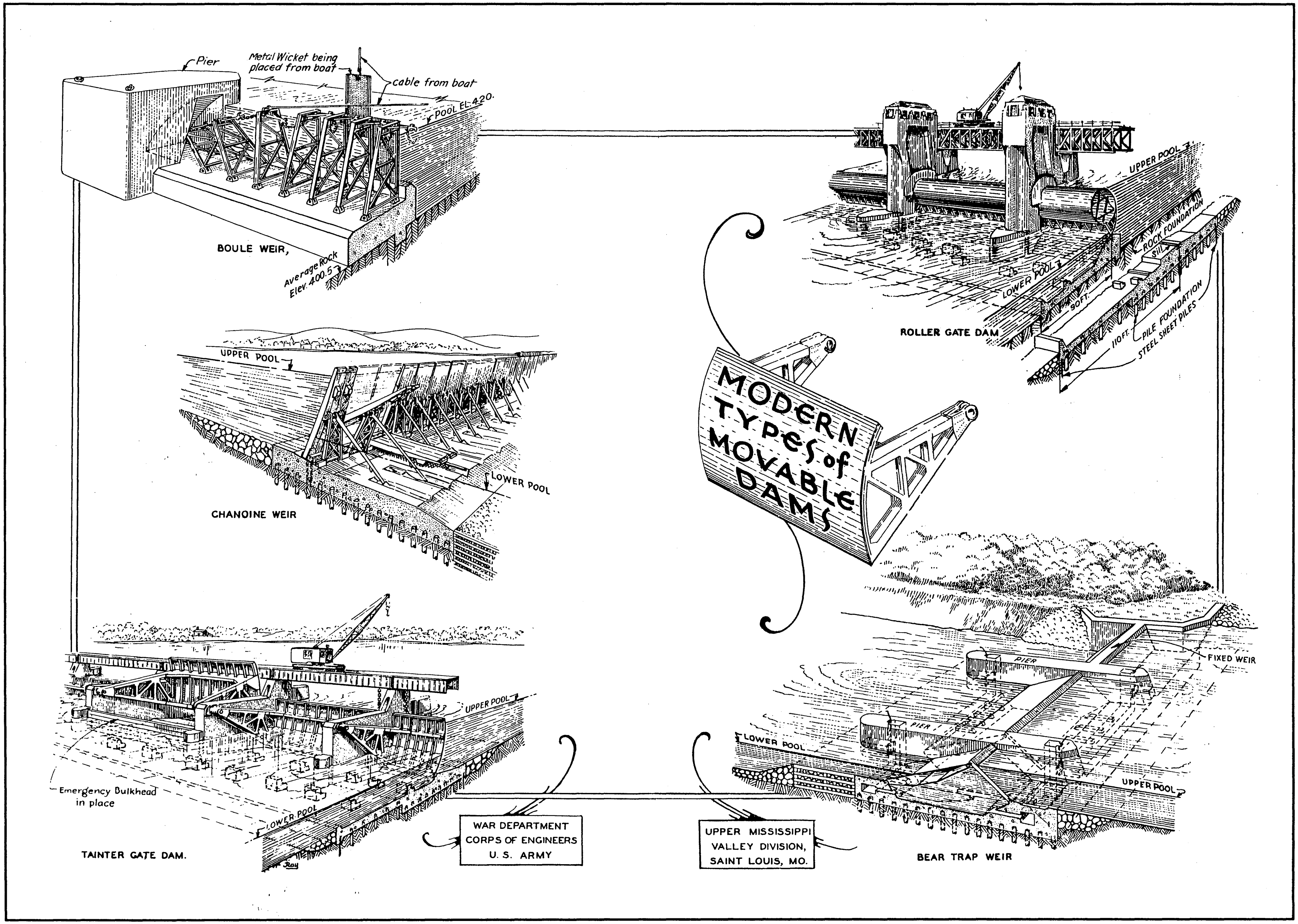
In 1900, a group of about 25 residents from the towns of Keokuk, Iowa, and Hamilton, Illinois--two Mississippi River towns located directly across from each other--incorporated themselves as the Keokuk and Hamilton Water Power Company with the express purpose of developing hydroelectric power. In 1901, the Federal Government gave permission to the company to build a wing dam on the Illinois side of the river. The Keokuk and Hamilton Water Power Company hired Lyman R. Cooley, a hydraulic engineer from Chicago, to develop specifications for the project. Cooley concluded that a wing dam was impractical, and that it would take a dam all the way across the river to effectively generate enough hydroelectric power to be a commercial success. Because the installation Cooley suggested included a navigation lock, it would also solve the long-standing navigation problems associated with the Des Moines Rapids.[8]

In June 1902, Congress asked the Corps of Engineers to determine if the Keokuk and Hamilton Water Power Company project would benefit or impede navigation on the Upper Mississippi River. Charged with this task, Montgomery Meigs concluded that the non-navigable dam at Keokuk would benefit river transportation, while allowing effective use of the river for hydroelectric power generation. Meigs acknowledged that 15 percent of the downstream river traffic went directly over the Des Moines Rapids, rather than passing through the existing by-pass canal and locks. But he also noted that the percentage of traffic using open river navigation was declining rapidly. Meigs predicted it would continue to do so as the Upper Midwest lumber industry declined, and the lumber marketing and processing facilities upstream from Keokuk came to increasingly dominate what was left of the business. By 1902, there was only one sawmill left below Keokuk.

Meigs also endorsed the plan because of new advances within the shipping industry. Developments in barge and towboat technology had made it possible to haul ore and grain in less cumbersome fleets. Moreover, long-distance packet boat operators had lost their battle with the railroads. By 1903, packet boats were no longer a significant user group on the Upper Mississippi River. As a result, Meigs advised Congress that the Keokuk installation, which included a non-navigable dam with one lock, would save time for the vast majority of river traffic. He also estimated that, had the facility existed between 1890 and 1901, river users would have saved 12,000 hours, which would have reduced shipping costs 0.6 cent per ton of freight.[9]

In February 1905, Congress gave permission to the Keokuk and Hamilton Water Power Company to build its dam and powerplant. By allowing this project, Congress and the Corps cleared the way for the later 9-Foot Channel Project. The Keokuk project, completed in 1914, established the precedent for non-navigable dams on the Upper Mississippi. It also showed that the free flow of the river could be interrupted in mid-stream without unacceptable damage to the river, surrounding lands, or economics.[10]

Despite the Keokuk project authorization, the Corps did not immediately begin



The U.S. Army Corps of Engineers refined several types of movable dam designs, suitable for different river characteristics and navigational needs. From "Engineering As Applied To The Canalization Of A River," prepared by the Office of the Division Engineer, Upper Mississippi Valley Division, St. Louis, Missouri, September 1935. (American Heritage Center, University of Wyoming)

The Ohio River 9-Foot Channel Project

When Corps engineers began designing the Upper Mississippi River 9-Foot Channel Project, much of what they knew about slack-water navigation was based on their experience canalizing the Ohio River. The Corps began the Ohio River Canalization in 1879, eventually installing 51 lock and dam structures on the river. As on the Mississippi River, the Corps designed the Ohio River project to secure a dependable 9-foot navigable depth. But the two projects differed from each other in a fundamental way. The Corps equipped the Ohio River with navigable dams. The dams on the Upper Mississippi River were non-navigable.[11]

The Corps designed the Upper Mississippi and Ohio River dams to reflect the unique characteristics of each river. The dams also reflect the technology available at the time of their construction. The Ohio River experienced extended periods of high water that permitted long periods of open river navigation, but necessitated dams capable of passing large amounts of water. Wicket dams, such as the Chanoine wicket dam constructed at the Davis Island site on the Ohio River, accomplished both of these ends. During periods of high water, Corpsmen laid the wickets flat, at a depth below the water level. The lowered wickets allowed for almost free passage of flood waters. River traffic could also pass directly over the top of the dam.

The non-navigable dams of the Upper Mississippi offered several advantages over the navigable wicket dams on the Ohio. Wickets had to be either fully raised or fully lowered. But the Corps could set the gates on the Upper Mississippi dams to any desired opening, permitting accurate regulation of pool heights. The higher sills of non-navigable dams also ensured a minimum pool level, an advantage in a shallow river such as the Upper Mississippi.

Skilled laborers, working in derrick boats, operated wicket gates. As such, the gates were dangerous, expensive, and difficult to repair. By contrast, lockmasters operated the dam gates on the Upper Mississippi mechanically, making them safer and more dependable. In addition, the individual gate bays could be easily closed off for repairs. Non-navigable dams also reduced hydraulic jump and downstream scour, two conditions that undermine dams.[12]

In the 1930s, the Corps began modernizing the Ohio River 9-foot channel. Corps engineers replaced the original wicket dams with non-navigable dams equipped with movable roller and Tainter gates, similar to those on the Upper Mississippi. By the 1950s, the Corps had also determined that the standard 110 by 600 foot locks of the Ohio River were inadequate, and that 110 by 1200 foot locks were better suited for modern, larger barge tows.[13]

building non-navigable dams elsewhere on the Upper Mississippi. In fact, the next major structure the Corps built on the Upper Mississippi--the Moline Lock, completed in 1908 and located 123 river miles upstream from Keokuk--was specifically designed for open water navigation. Similarly, in 1913, when the Corps developed plans for a lateral canal and lift lock to allow circumnavigation of the Le Claire section of the Rock Island Rapids, it continued to ensure open river navigation. Congress authorized construction of the Le Claire Canal in March 1914. However, the outbreak of war in Europe dashed any hopes for a quick startup. When, by the summer of 1920, construction had still not begun, the Corps took this opportunity to re-examine its designs for the canal and lock in light of recent developments in waterway technology. Interestingly, the Corps continued its commitment to open water navigation. The 1921-1924 construction of the Le Claire Canal and its appurtenant structures in no way hampered open water navigation.[14]

The Corps remained committed to open water navigation on the Upper Mississippi in 1925 when plans were made for a lock and dam complex at Hastings, Minnesota. However, this structure, built between 1928 and 1930, did not leave as much room for open water maneuvering as the Moline and Le Claire installations. The Hastings complex (now known as Lock and Dam No. 2) only included a 100-foot-wide navigable pass adjacent to the lock. It also included 20 Tainter gates. In narrowing the space reserved for open river navigation and utilizing Tainter gates for the first time on the Upper Mississippi River, the Hastings Lock and Dam acted "as a sort of engineering link" between the Corps' 6-foot channel structures and philosophy and its mature 9-foot channel structures and philosophy.[15]

In its final survey report of the 9-Foot Channel Project, the Corps' special Board of Engineers noted that it had considered three methods of securing a 9-foot depth on the Upper Mississippi: (1) regulation and dredging; (2) a combination of reservoirs, regulation works, and dredging; and (3) canalization by locks and dams. The first system, regulation and dredging, was the primary method used to obtain the 6-foot channel. Although the survey report acknowledged that "modern self-propelled dredges" could supplement regulation works, it also noted that regulating the flow of the river through contraction works such as wing and closing dams would be impractical on many stretches of the river. The survey team also studied the feasibility of a storage reservoir system on the Upper Mississippi River. Although at least 34 possible reservoir sites were identified, the Corps concluded that even if that many reservoirs were operated as a unit, they would still not ensure a dependable 9-foot channel depth, even if supplemented by regulation and dredging during dry years.[16]

Just as Major Hall had concluded in his initial survey of the Upper Mississippi River project, the special Board of Engineers determined that a slack-water navigation system was the most feasible method of obtaining a 9-foot depth. By early 1930, Corps engineers had also begun to reconsider their commitment to open water navigation on the Upper Mississippi. In March of that year, Minnesota Representative William I. Nolan proposed legislation that would give the Corps the right to make changes in the type and location of the 9-Foot Channel Project dams. Clearly, the Corps was beginning to consider the use of non-navigable dams.[17]

CHAPTER FOUR NOTES

1.Leland R. Johnson, The Davis Island Lock and Dam 1870-1922 (Pittsburgh: U.S. Army Corps of Engineers, Pittsburgh District, 1985) 8-9, 13, 16, 25-26, 34-36; Johnson, The Falls City Engineers: A History of the Louisville District Corps of Engineers, United States Army (Louisville: U.S. Army Corps of Engineers, Louisville District, 1974), 98-99, 142-143, 147-148; and Louis Hunter, Steamboats on the Western Rivers, An Economic and Technological History (Cambridge: Harvard University Press, 1949), 206-212.

2.Hunter, Steamboats, 566-584.

3.For general information on log and raftboat movement on the Upper Mississippi see Tweet, Rock Island District, 238-243; William J. Peterson, "Rafting on the Mississippi: Prologue to Prosperity," Iowa Journal of History 58, No. 4 (1960): 289-320; Robert F. Fries, Empire in Pine: The Story of the Lumbering Industry in Wisconsin, 1830-1900 (Madison: State Historical Society of Wisconsin, 1951), 8-59; Agnes M. Larson, History of the White Pine Industry in Minnesota (Minneapolis: University of Minnesota Press, 1949), 3-70; and Charles E. Twinning, Downriver, Orrin H. Ingram and the Empire Lumber Company (Madison: State Historical Society of Wisconsin, 1975), passim.

4.Merritt, Creativity, Conflict and Controversy, 69-93; and Ellis Armstrong, ed., History of Public Works in the United States 1776-1976 (Chicago: American Public Works Association, 1976), 35.

5.Gjerde, "St. Paul Locks and Dams," 117-119; and Merritt, Creativity, Conflict and Controversy, 141-146.

6.Completed in 1903, Montgomery Meigs's report was published in 1916. See "Report of Mr. Montgomery Meigs, U.S. Civil Engineer," Annual Report, 1916, Vol. II (hereafter referred to as Meigs Report), 1509. (Beginning in 1867, the Federal Government started printing and binding the Annual Report to the Chief of Engineers. Published at the end of the fiscal year, the exact title and format of the series has varied slightly from time to time. Hereafter all reports from this series will be referred to as Annual Report, followed by the fiscal year which the report covers.) For a more complete biography of Meigs, see Tweet, Rock Island District, 357-358.

7.Samuel P. Hays, Conservation and the Gospel of Efficiency: The Progressive Conservation Movement 1890-1920 (Cambridge: Harvard University Press, 1959, reprinted with a new preface by the author, New York: Antheneum, 1974), 93-94, passim; Johnson, Louisville District, 170; George Whaton James, Reclaiming the Arid West: The Story of the United States Reclamation Service (New York: Dodd, Mead, and Company, 1917); The U.S. Reclamation Service: Its History, Activities and Organization (New York: D. Appleton and Co., 1919); and Alan R. Dickerman, George E. Radosevich, and Kennet Noble, "Foundation of Federal Reclamation Policies: An Historical Review of Changing Goals and Objectives" (Ft. Collins: Department of Economics, Colorado State University, 1970).

8.Nelson C. Roberts and S. W. Moorhead, Story of Lee County, Iowa (Chicago: The S.J. Clarke Publishing Company, 1914), 243-254; Tweet, Rock Island District, 245; and Rivers and Harbors Act of June 13, 1902.

9.Meigs Report, 1509.

10.Ibid.; and Tweet, Rock Island District, 246.

11.Johnson, Davis Island Lock and Dam, 37-41, 133; Michael C. Robinson, History of Navigation in the Ohio River Basin: National Waterways Study: U.S. Army Corps of Engineers Water Resources Support Center, Institute for Water Resources--Navigation History NWS-83-5 (Washington D.C.: Government Printing Office, 1983); Clarence Newman, Ohio River Navigation: Past, Present, Future (Cincinnati: U.S. Army Corps of Engineers, Ohio River Division, 1979), 23-24; Tweet, Rock Island District, 103; and L.E. Wood, "A Nine Foot Depth Below St. Anthony Falls!", Old Man River 5, No. 5 (n.d.) 2-8, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, National Archives, Kansas City Branch (hereafter referred to as NAKCB).

12.Roberts, "Kanawha River," 337-338; Daley, "Canalization of Upper Mississippi," 105; McAlpine, "Roller Gates in Navigation Dams," 419; Gross and McCormick, "Upper Mississippi River Project," 313-314; and Malcolm Elliot, "The Upper Mississippi River Project with a Discussion of the Movable Gates in the Dams," paper presented at the Western Society of Engineers, Chicago, November 1, 1937, 4-5, in RG77, subgroup: St. Paul District, General Records 1934-1943, Box 40, Entry 1629, File 4013.1/113, NAKCB. Hydraulic jump is a phenomenon associated with the tendency for water flowing over a structure to fall in a determinable curve. If the curve of the water falls well beyond the face of the structure a vacuum can form that literally sucks the concrete or other building material from the structure. Careful design and the provision of baffles and settling basins serve to reduce and control hydraulic jump. Scour is a condition that results from water passing over a structure and rolling along the riverbed below the structure. The force of the water can excavate large holes in the riverbed, ultimately undermining the structure. The downstream apron, derrick stone protection, and baffles reduce the force of the water.

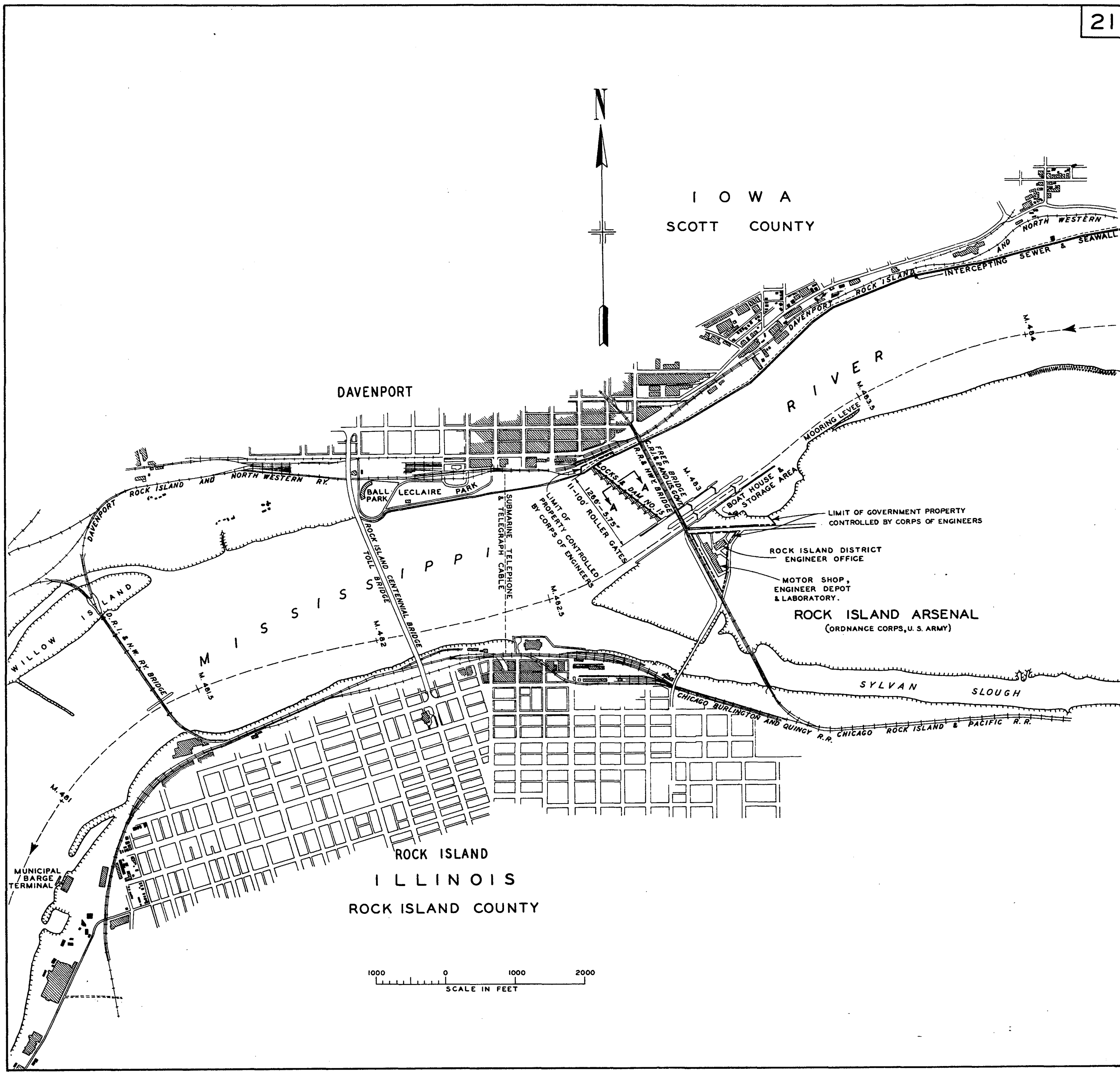
13.Newman, Ohio River Navigation, 36-37.

14.Ibid., 142-144; Rivers and Harbors Act, March 5, 1915; Richard Monroe to H. Burgess, June 9, 1920, and H. Burgess to Division Engineer, July 24, 1920, RG77, Entry 81, Box 798, NACB.

15.Gjerde, "St. Paul Locks and Dams," 125.

16.H. Doc 137, 4.

17.Ibid.; S.G. Roberts, "Roller-Gate Dams for the Kanawha River," Engineering News Record 111, No. 21 (September 21, 1933), 338, 340; and George R. Spalding to Chief of Engineers, February 9, 1930, RG77, District Files, 1923-1942, Box 825, File 2294, NA.



Lock and Dam No. 15, the first complex of the 9-Foot Channel Project, was located in the heart of the quad cities, raising local concerns about flooding and water quality. (U.S. Army Corps of Engineers)

CHAPTER V

1929-1933: The Project Begins

In October 1929, as part of a general reorganization, the Corps of Engineers created the Upper Mississippi Valley Division (UMVD). The UMVD supervised the activities of 12 Corps district offices, including the three located along the Upper Mississippi River: the St. Paul District, the Rock Island District, and the St. Louis District. Following the authorization of the 9-Foot Channel Project, each of these three district offices oversaw the construction of the channel on a particular stretch of the Upper Mississippi. The St. Paul District was charged with supervising the project between St. Paul and the Wisconsin River. The Rock Island District covered the river between the Wisconsin River and Clarksville, Missouri. And the St. Louis District directed activities between Clarksville and St. Louis. The St. Louis District also served as the headquarters of the UMVD.

As originally planned, the Upper Mississippi Valley Division was to design the major elements of the 9-Foot Channel Project, relegating design of "less critical" elements and construction supervision to the three districts. The districts were also responsible for estimating and contract administration, construction supervision, and operation. To accomplish these tasks, the districts expanded their technical engineering expertise, and increased their contract administration sections. They also added resident engineers for each complex, as well as on-site supervisory, administrative, and inspection staffs.[1]

Heading the UMVD was Lieutenant Colonel George R. Spalding. Spalding had been a member of the special Board of Engineers that had conducted the "more thorough" survey of the 9-Foot Channel Project. Immediately prior to his appointment as Division Engineer of the UMVD, Spalding served as District Engineer of the Louisville District, which was just finishing the construction of the 9-foot canal on the Ohio River. The Ohio River canal had been created through a series of locks and dams, and Spalding certainly could have seen the potential for the Ohio River's very experienced and capable engineering team to be used on a similar project on the Upper

Mississippi River.

Spalding selected William H. McAlpine to be Head Engineer of the UMVD. McAlpine had been Spalding's principal civilian assistant in the Louisville District. Although ultimate responsibility for the Corps' civil works and military construction units rested with the Corps' military officers, individual projects--no matter how big--were generally overseen by a civilian. The normal tour of duty for a military officer was 3 years. Consequently, a district or division's top management changed frequently. It was the long-term civilian employees, like McAlpine, who provided continuity. At the time of his transfer to the UMVD, McAlpine was also considered to be the Nation's expert in river improvement.[2]

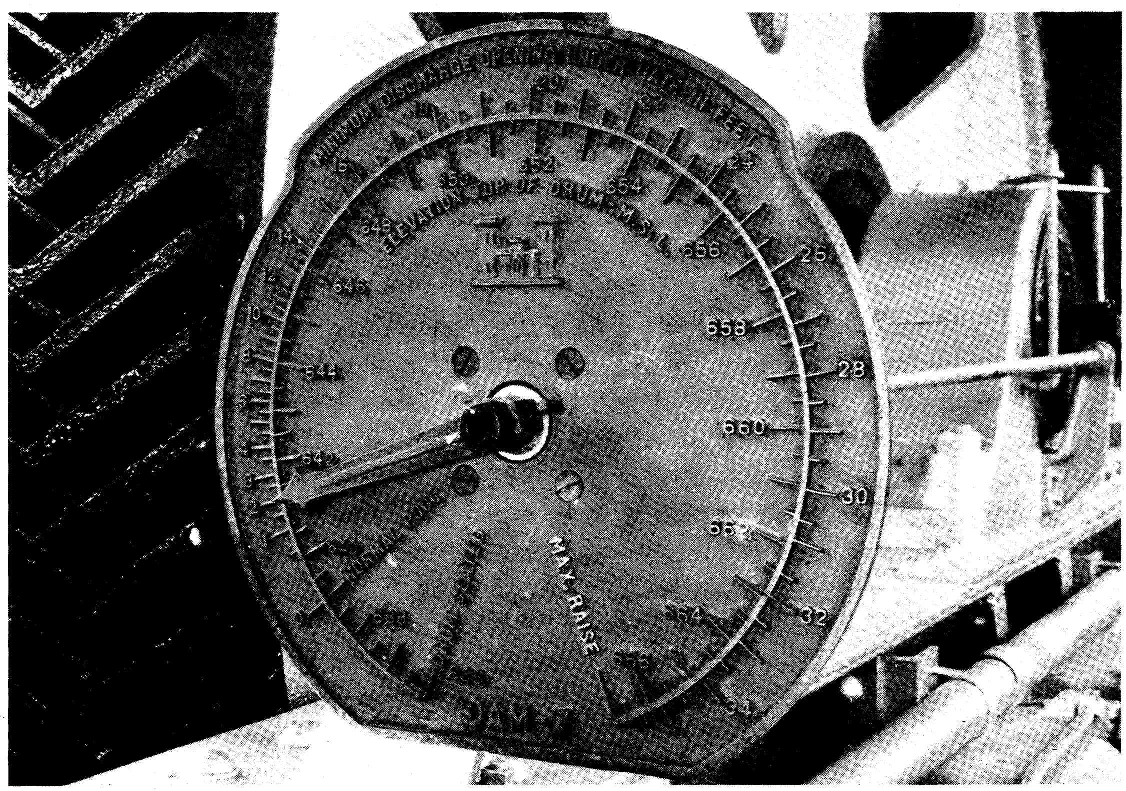
As head of the UMVD design team, William H. McAlpine became one of the principal engineers of the 9-Foot Channel Project. McAlpine's career as a civilian engineer attached to the U.S. Army Corps of Engineers spanned over 50 years. Born in Massachusetts in 1874, he began working for the government in 1899 as a hydrographic surveyor. By the time he retired from the Corps in 1954, he had served on numerous special projects including work as a consultant to the Panama Canal Office, the Fort Peck and Bonneville Dam projects, and the Tennessee Valley Authority. In 1943, McAlpine participated in conferences between the U.S. and Great Britain regarding the feasibility of constructing artificial harbors for the proposed landing of Allied troops at Normandy. Achieving the highest civilian post in the Corps of Engineers, McAlpine was awarded the Emblem for Exceptional Civilian Service in 1946.

By the end of November 1929, Spalding and McAlpine had begun reassembling the old Louisville design team in the St. Louis headquarters of the UMVD. Among the engineers transferred from Louisville to St. Louis were Lenvik Ylvisaker and Edwin E. Abbott. Like McAlpine, Ylvisaker had a degree from the Massachusetts Institute of Technology. In Louisville, Ylvisaker had been McAlpine's right hand man, and he served in a similar position in the UMVD. Edwin Abbott was Ylvisaker's assistant. The UMVD team assembled by Spalding designed some of the most critical components of the 9-Foot Channel Project. Although the individual districts eventually assumed a more important role in the design process, the designs of the UMVD under the leadership of Spalding and McAlpine served as prototypes for the 9-Foot Channel Project.[3]

In 1931, the UMVD design team completed construction drawings for the first two installations: Locks and Dams Nos. 4 and 15. Both of these projects were considered high priority. After years of planning and negotiating, it seemed as though the Corps of Engineers would finally be able to build the channel. But, once again, the 9-Foot Channel Project was called into question.

On December 22, 1930, the Corps of Engineers held a public meeting regarding its preliminary plans for Lock and Dam No. 15. The complex was located at the foot of the Rock Island Rapids in the heart of the quad-cities of Moline and Rock Island, Illinois, and Davenport and Bettendorf, Iowa. Despite navigation improvements, the stretch of river from the Moline Lock to the foot of the Rock Island Rapids was still extremely hazardous. The Moline Lock, which had been completed in 1908, was also small, 80 by 300 feet. As a consequence, operators were forced to break tows into "lockable" pieces and then reassemble them. The Corps of Engineers designed Lock and Dam No. 15 to solve these problems, at least up to the site of the Le Claire Lock.

At the public hearing, Rock Island city officials expressed concern that if Lock and Dam No. 15 were built in its proposed location, the city would have to draw its water from the pool behind the dam rather than from the river. This raised the specter of health problems. Local officials also objected to the proposed locations of the lock and guidewall because they would "have the effect of putting Rock Island in the backyard of the Mississippi River."[4]



The elevation gauge at Dam No. 7 is geared for a maximum pool height of 667 median sea level (m.s.l.). Conservationist groups, such as the Izaak Walton League, argued that higher pool elevations in the 9-foot channel would adversely impact the Upper Mississippi River Valley environment. (Clayton B. Fraser, Fraserdesign)

Rock Island officials were not the only ones who saw problems with the Lock and Dam No. 15 complex. Moline officials were afraid the dam would flood their industrial areas. The complex would also adjoin the northwest tip of Arsenal Island, home of the U.S. Army's Rock Island Arsenal. U.S. Army Ordnance Colonel D.M. King expressed official concern that the proximity of the lock and dam to the government bridge leading to the Rock Island Arsenal would affect access to that installation, as the swing span would have to be open much of the time.[5]

There was also opposition to Lock and Dam No. 4, located near Alma, Wisconsin. Here, the controversy focused on the pool elevation. Health and environmental experts claimed that the structure's navigation pool, which would raise the water level of the river and inundate previously non-inundated land, would hurt the river valley environment. At a public hearing on February 26, 1931, the Corps agreed to lower the pool from 670 median sea level (m.s.l.) to 667 m.s.l. The 3-foot variance guaranteed substantial protection from an otherwise negative impact. However, the Corps wanted the dam structure to be "readily adaptable" to 670 m.s.l. in the event that it was necessary to raise the elevation. If the pool did have to be raised, the Corps assured that "ample time" would be given to all concerned to take the necessary "protective measures."[6]

These assurances, however, did not satisfy conservationists. In March 1931, the national organization of the Izaak Walton League held a meeting in Winona, Minnesota, that focused public awareness on the issue and intensified pressure to lower the proposed water elevation. Had the conservationists been alone in their protests, they may have been unable to lower the pool elevations. But they were not alone. Simultaneously, a number of railroad companies--seeing both a long range threat to their freight transport business from increased river commerce, and a more immediate threat to their riverside properties from the higher pool elevations--began fighting the project. Unlike the conservationists, however, the railroads did not content themselves with merely holding meetings and passing resolutions.

In 1931, the Chicago, Burlington, and Quincy Railroad (CB&Q) sued the Federal Government regarding the navigation pool behind Lock and Dam No. 4. The railroad claimed that the pool would damage its right-of-ways. The Corps did not dispute the claim, but hoped for a financial settlement with the railroads. But in their arguments before the U.S. District Court for the Western District of Wisconsin, the CB&Q's attorneys asked for neither money nor a mitigation of damages. Rather, they asked that the Federal Government be barred from building Lock and Dam No. 4. The railroad's lawyers pointed out that the 1930 authorization permitted the Corps to build the system described in House Document 290. The Corps' 1931 plans were quite different: they included non-navigable rather than navigable dams. The CB&Q's attorneys contended that this change constituted a radical difference in nature and kind. The court agreed and, in early 1932, enjoined the Corps from building Lock and Dam No. 4.[7]

The judgment alarmed the Corps of Engineers. If the courts could suspend construction of an individual lock or dam because it differed from the original plans, the entire 9-Foot Channel Project could be brought to a halt. The Corps always knew that the 9-foot system, as outlined in House Document 290, might need modification, particularly in the downstream sections of the project. The original plans were made without the benefit of detailed site specific surveys. But, following the CB&Q ruling, if the Corps made *any* design changes, the railroads could get similar injunctions at most, if not all, of the other proposed lock and dam complexes. UMVD Division Engineer Spalding suggested that the U.S. attorney general's office retain attorneys with specialized legal expertise on railroad matters. "The railway companies, with their fine legal talent, are doing this very thing," argued Spalding. "They are fighting these cases jointly by exchanging briefs and combining defenses to defeat the government."[8]

The Corps of Engineers needed a way to prevent the railroads from pursuing this strategy. House Document 290 had outlined and authorized the specific administrative parameters for the 9-Foot Channel Project. The Corps now sought to amend the 1930 authorization to give the Chief of Engineers the power to make changes in the original plans. On February 24, 1932, Congress and President Hoover signed into law a joint resolution that gave the Corps the right, at its professional discretion and without additional approval, to change the type and location of the lock and dam systems.[9]

Corps officials wasted no time in implementing the new authority. The lawsuit regarding Lock and Dam No. 4 was quickly dismissed. In early March 1932, Attorney General William D. Mitchell made it clear to the U.S. attorney at Madison, Wisconsin, that "the case is moot and to move for a mandate to the Court below to dismiss the case."[10]

Engineers for the 9-Foot Channel Project were now free to modify plans without the threat of lawsuits. Concessions, however, had been made along the way. To alleviate damage to railroad right-of-ways, as well as to the river valley environment, the Corps had also agreed to lower the pool elevations. Almost a year to the day after the 1931 public hearing on Lock and Dam No. 4, a change in plans by the Corps of Engineers called for the pooling of waters at no more than 667 m.s.l. Previous rhetoric about possible future needs to raise water levels was noticeably absent. Strange bedfellows, the railroads and conservationists had together, but for entirely different reasons, succeeded in altering the design of the 9-Foot Channel Project.

CHAPTER FIVE NOTES

1.In 1933, the Corps of Engineers created the Ohio River Division (ORD) and the Missouri River Division (MRD), thereby reducing the territory covered by the UMVD.

2.Johnson, Louisville District, 182-183; and Civil Works Study Board, "The Interrelationship Between Civil Works and Military Mission," Annual Report 1965, 27-30.

3.Transfer approvals for Ylvisaker and Abbott are contained in Chief of Engineers Lytle Brown to Colonel George R. Spalding, November 30, 1929, RG 77, District Files, 1923-1942, Box 825, File 2294, NA. Information on Ylvisaker's education and his role in Louisville comes from interviews by Leland R. Johnson and Charles E. Parrish with Oren Bellis, Louisville, KY, June 6, 1986, as cited in Leland R. Johnson to William Patrick O'Brien, February 6, 1988 (first letter of that date) copy in files of National Park Service, Rocky Mountain Regional Office.

4."U.S. Engineer Office, Improvement of Mississippi River, Development Near Rock Island, Illinois, Hearing on December 22, 1930," typescript, 67, RG77, Entry 81, Box 798, NACB.

5.When the final construction plans for Lock and Dam No. 15 were completed, they included remedial works. The Corps decided to build a 2-mile long reinforced concrete seawall with an integral, intercepting sewer and a 4.5 mile long earthfill levee enclosing the continuation of this intercepting sewer along the Davenport and Bettendorf waterfronts as part of the project. It also decided to build a raised levee along a portion of Arsenal Island, an intercepting sewer for Arsenal Island, and an extension of the water supply intake pipe for the City of Rock Island. H. Doc. 137 as cited in "Mississippi River Lock and Dam No. 17: Final Report Construction," Vol. I: "Introduction, Lock and Temporary Buildings" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, March 1938, hereafter cited as "Final Report-Lock 17"), 4-5, RG77, Entry 81, Box 666, NACB; and "Final Report Lock and Dam 15," 7.

6.Lieutenant Colonel Wildurr Willing, Major Glen E. Edgerton, W.H. McAlpine to Division Engineer, UMVD, St. Louis, April 21, 1931, "Report: Public Hearing--Alma Dam," 1-30, passim; W.H. McAlpine to Col. Wildurr Willing, April 30, 1931; Lieutenant Colonel George R. Spalding to Chief of Engineers, Washington D.C., May 28, 1931, 1-5; Lieutenant Colonel Wildurr Willing, "Notice to the Press and Interested Parties," August 3, 1931; Transcript: Hearing at Wabasha, Minnesota, February 26, 1931, re: construction of dam at Alma, Wisconsin, 1-31, RG 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry 1626a, File 413.b, NACB.

7.<u>Hearings</u>, January 1932, 6-10; Congress, House, Committee on River and Harbors, <u>Mississippi River to Minneapolis--Decree of Injunction Restraining the Government From Construction of a Lock and Dam at Alma, Wis.</u>, H. Doc. 7, 72nd Cong., 1st sess., 1932; and H. Doc. 290.

8.Colonel George R. Spalding to Chief of Engineers, U.S. Army, Washington D.C., March 24, 1932.

9.Congress, House, <u>Public Resolution No. 10</u>, H.J. Resolution 271, 72nd Cong., 1st sess., 1932; Memo: "Modification of Plans, Lock and Dam No. 4, Miss. River, in accordance with H.J. Res. 271;" and George R. Spalding to Chief of Engineers, February 29, 1932, 1-4, RG77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry 1626a, File 413b.3, NACB.

10.William D. Mitchell, Attorney General, to Patrick J. Hurley, Secretary of War, Mar. 8, 1932, RG77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry 1626a, File 413b.3, NACB.

During the Great Depression, the Upper Mississippi River 9-Foot Channel Project was seen as an opportunity to provide thousands of much-needed jobs. Among the lucky ones to be working were J.B. Paulson and H. Carlson, inspection personnel for Lock and Dam No. 4, c. 1936. (American Heritage Center, University of Wyoming)

CHAPTER VI

1933: The New Deal and a New Emphasis on Public Employment

The Great Depression reached its nadir during the winter of 1932-1933. The national political mood was clear: all civil works projects that could not be modified to serve a major relief work purpose would be abandoned. The 9-Foot Channel Project came under cancellation consideration during the special session of Congress that President Franklin D. Roosevelt called as part of his "First 100 Days." Iowa Representative Edward C. Eicher introduced a bill calling for the abandonment of the 9-Foot Channel Project during a 4-day congressional hearing in May 1933. Also leading the opposition were Iowa Representative Fred Bierman, and A.C. Willford, an Iowa congressman and a national and state Izaak Walton League director. Bierman and Willford did not argue the 9-Foot Channel Project's potential for employing significant numbers of people in an area with acute unemployment. Rather, they opposed the 9-Foot Channel Project on environmental, Progressive, and recovery approach grounds.

The 9-Foot Channel Project was attacked on several fronts. Conservationists argued that it would flood most of the 90,000-acre Upper Mississippi Wildlife Refuge that had been created by President Calvin Coolidge in 1924. Progressive politicians were concerned that the project would over-industrialize the Upper Mississippi River Valley. Others claimed that a government-funded waterway improvement on the Upper Mississippi was in direct opposition to New Deal principles, as represented by the National Industrial Recovery Act that was simultaneously being debated in Congress. They argued that an existing, locally important, tax-paying industry--the railroads--should not be forced to compete with improved, not-directly-taxable, river transportation.[1]

Key witnesses supporting the project were A.C. Wiprud, General Counsel for the Upper Mississippi Waterways Association of Minneapolis (the successor organization to the Upper Mississippi River Barge Lines Company), and Minnesota Governor Floyd B. Olson. Charging that it was the railroads that were instigating all opposition to the project, Wiprud argued in the project's favor because it could employ large numbers of people. Governor Olson saw the principal benefit as lower rail rates. Chief of Engineers Lytle Brown, in a masterly demonstration of official neutrality, limited his remarks to the engineering feasibility of the project, what he termed the Corps' real area of expertise. Although the Corps routinely commented on project economics, Brown refused to comment on the economic benefits of the 9-Foot Channel Project--either in terms of rail rates, emergency employment opportunities, industrial revival, or industrial development--and only tangentially dealt with the environmental issues.[2]

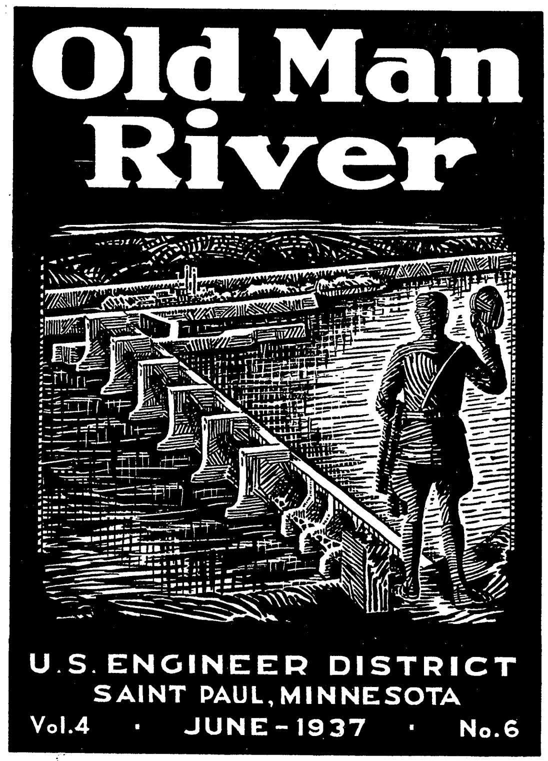
No specific legislation or direct congressional orders came out of these hearings. But, as so frequently happens, key government agencies and people apparently arrived at a consensus out of public sight. Conceived of as a means of improving navigation on the Upper Mississippi, the 9-Foot Channel Project was now hailed as an opportunity to provide thousands of jobs. The Corps of Engineers, in a skillful display of bureaucratic flexibility, had successfully recast the project to suit the goals of the new administration.

The U.S. Army Corps of Engineers constructed the 9-Foot Channel Project during the Nation's greatest economic depression, which affected the program in a number of ways. The emphasis on employment put the Corps and the Upper Mississippi River 9-Foot Channel Project at the forefront of Federal relief work projects. In 1935, at the height of its involvement with emergency relief monies, the Rock Island District alone had 11 National Industrial Recovery Act, Public Works Act, Emergency Relief Appropriation Act, and/or Works Progress Administration funded projects underway. In addition, because of their river channel locations, each 9-Foot Channel Project was in the jurisdiction of two National Reemployment Labor Offices, each part of a different state bureaucracy. Typically, two general contractors and numerous sub-contractors worked at each 9-foot channel location. In the Rock Island District alone, these contractors employed over 10,000 men. Presidential advisor Harry Hopkins, who administered the Federal Emergency Relief Administration, acknowledged the Corps' expertise in Federal relief work in 1935, when he was organizing the Works Progress Administration (WPA). In October of that year, Major Raymond A. Wheeler, Rock Island District Engineer, was assigned to serve as Chief Regional Administrator of the WPA. Colonel George Spalding also served with the Works Progress Administration at the national level.[3]

But the Federal monies brought an added burden to the Corps of Engineers. Relief projects were geared towards maximum employment rather than efficiency. In addition, relief funds came with complicated employment, recruitment, and labor requirements. The independent contractors who worked on the 9-Foot Channel Project often resented these elaborate rules and regulations, seeing them as obstructions to the profitable completion of their contracts. Corps officials had to contend with numerous problems relating to contractor compliance, particularly in terms of hiring practices, time delays, overtime, and claims of changed conditions.

In some instances, the disagreements led to lawsuits. At Lock and Dam No. 12, the contractors sued the Federal Government, claiming that the government had not provided enough skilled and unskilled labor for contractors to hire while, at the same time, limiting where they could secure workers. The enormity of the problem is reflected in the size of the claims. The James Stewart Corporation sued the Federal Government for $314,114.66, almost 25 percent of its $1,346,720.83 contract.[4]

Maxon Construction Company, the general contractor for Dam No. 12, sued not only on that project, but also on its Lock No. 18 contract. Maxon Construction's president, G.W. Maxon, had over 25 years experience in river construction, most of which was for the Corps of Engineers. Maxon was familiar with Corps procedures and its classification of employees. However, Maxon was not prepared to deal with Federal relief work rules. Maxon believed that Federal relief workers were often unqualified, so he hired other workers. But the Federal Government withheld payment for these unauthorized employees. Maxon argued that unqualified workers increased his costs because of the high risk of accidents which, in turn, raised his liability insurance premiums and caused him to miss project deadlines. Maxon's cases ended up in the U.S. Court of Claims. The court awarded Maxon more than $100,000 on his Lock No. 18 claim, an amount equal to about seven percent of the contract.[5]



The St. Paul District published a monthly periodical, Old Man River, to promote safety practices among the employees. (American Heritage Center, University of Wyoming)

Contractors' fears about unskilled labor were well-founded. Under the Economic Recovery Act and related programs, a great number of untrained laborers were hired to work on the Upper Mississippi River locks and dams. And as the contractors claimed, these workers increased the possibility of accidents. Throughout the course of the 9-Foot Channel Project, the Corps of Engineers endeavored to maintain safety standards at all of the construction sites.

Each district office implemented safety regulations. In the St. Paul District, Corps officials produced a monthly periodical, Old Man River, to not only keep all personnel abreast of various project developments but also, as advertised on its own sub-banner, "to promote safety among District and Contractor's employees." The Rock Island District published a similar newsletter, entitled The Safe Channel. St. Paul District officials also promoted safety by offering classes in which workers participated in demonstrations of safety equipment such as hard hats, safety shoes, and kapok life vests. District engineers displayed charts noting the number of accidents at each lock and dam project, and the number of man-hours lost to accidents. As the projects neared completion, concern over safety did not diminish. Bulletins establishing safety procedures, district safety meetings, and tours of facilities continued to be items of importance. Unfortunately, however, construction-related deaths were not uncommon. Between November 30, 1934, and December 31, 1937, 11 accidental deaths occurred at the St. Paul District.[6]

The Corps of Engineers photographed all aspects of Upper Mississippi River navigation improvement. The life vests worn by the photographers reflect the Corps of Engineers' emphasis on safety. (U.S. Army Corps of Engineers, Rock Island District)

Corps officials painstakingly documented the construction of the 9-foot channel. In the course of the 10-year project, the documentation reached gigantic proportions, encompassing thousands of maps, drawings, and records. Detailed engineering logs documenting the erection and assembly of the complexes, weather conditions affecting work, and pertinent data relating to the project's successful prosecution became part of the public work record. Officials in the district offices also made motion pictures of the construction progress. In July 1935, the St. Paul District office purchased a 16-millimeter Cine Kodak Special motion picture camera. Two 400-foot reels were produced entitled "Mississippi 9-Foot Channel Project." The Corps showed the picture so often and it was received so favorably that an additional project of greater scope was attempted. The St. Paul District made two additional films, one devoted to technical questions for engineering schools, the other for general audiences. Of the almost 19,000 feet of film shot, approximately 16,000 feet related to actual lock and dam construction. The Corps edited this raw material into twelve 400-foot reels with running times of approximately 15 minutes. Films of 4,800 feet were made for technical audiences; 2,400-foot films were assembled for non-technical viewing.[7]

The Rock Island District photographically documented the project's construction in both high-quality, 8 by 10 format, black and white, still photographs, and 16-millimeter silent movies. The Rock Island District constructed a photo lab in its Clock Tower Building, and the archives of that district contain at least 80 reels of film documenting the construction of Locks and Dams Nos. 1 through 22. The films vary in length from 20 minutes to over 1 hour.[8]

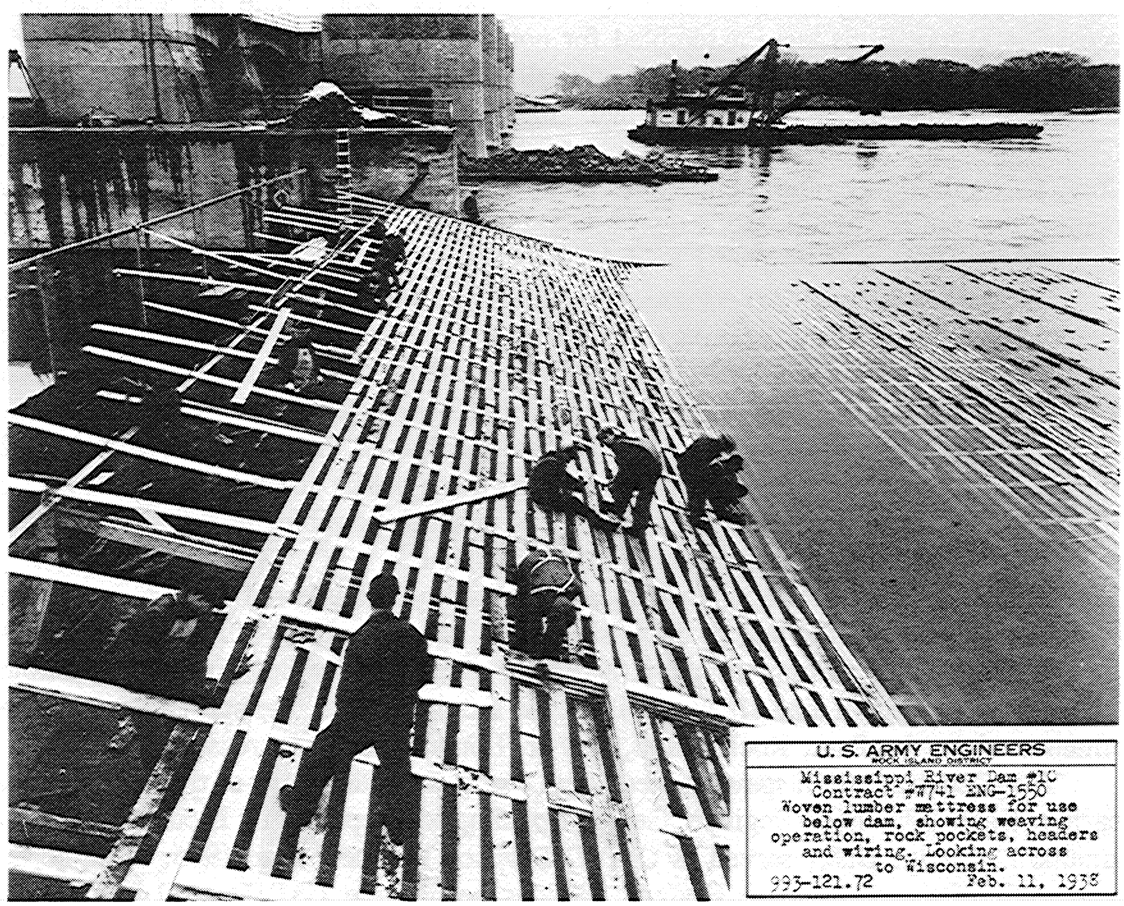
The 9-Foot Channel Project's new emphasis on employment had yet another effect: it encouraged the decentralization of the design process. At the 1933 congressional hearing, Chief of Engineers Lytle Brown had explained that he could achieve maximum employment by starting the 23 as-yet-unstarted 9-Foot Channel Project complexes simultaneously. His assistant, Brigadier General George B. Pillsbury, added that all 23 sites could be started within 4 months. To honor these public commitments, Brown and Pillsbury now had to decentralize the project as much as possible, so that the maximum number of tasks could be undertaken at the same time.[9]

Following the hearing, Brown and Pillsbury transferred survey and land acquisition, as well as the rest of the design work, from the UMVD to the districts. As a result, the UMVD design team that had been assembled by Spalding and McAlpine was greatly reduced in size after mid-1933. At the same time, the staff, activities, and influence of the St. Paul, Rock Island, and St. Louis Districts increased.

The decentralization spawned personnel changes. Within days of the congressional hearing, UMVD Division Engineer George Spalding was replaced by Lieutenant Colonel Edmund L. Daley. Daley served as UMVD Division Engineer until 1935, when he was replaced by Colonel John N. Hodges. Hodges headed the UMVD until 1938, when Lieutenant Colonel Malcolm Elliot assumed command of the division. Except for a brief period in 1939, when Lieutenant Colonel Phillip B. Fleming was Acting Division

Engineer, Elliot served as UMVD Division Engineer for the rest of the 9-Foot Channel Project.[10]

In 1933, Head Engineer William McAlpine accepted a transfer to the engineering section of the Chief of Engineers' office. Lenvik Ylvisaker resigned from the Corps. Edwin E. Abbott transferred to the Rock Island District. Neither a new head engineer, nor designers and technical engineering specialists such as Ylvisaker and Abbott, were assigned to the division office. Rather, Corps officials created a new administratively oriented position of Assistant Division Engineer. Major William A. Snow was the first UMVD Assistant Division Engineer, serving from 1933 until 1935. Major Bartley M. Harloe was UMVD Assistant Division Engineer from 1935 to 1936. Captain Emerson C. Itschner, who later served as Chief of Engineers from 1956-1961, was UMVD Assistant Division Engineer from 1936 to 1937. Captain Reginald L. Dean assumed the position in August 1937, and saw the 9-Foot Channel Project to completion.[11]



The Corps' construction photographs, such as this one taken at Dam No. 10 on a cold February day in 1938, are an important record of the working conditions and construction techniques of the 9-Foot Channel Project. (U.S. Army Corps of Engineers, Rock Island District)

CHAPTER SIX NOTES

1.Hearings, May 1933, 4-5, 7, 77. Beginning in April 1933, various people attempted drafts of what became the National Industrial Recovery Act. Debate continued throughout April and early May. Roosevelt presented a draft to Congress on May 17. He did not sign the resulting act until June 16, 1933. William E. Leuchtenburg, Franklin D. Roosevelt and the New Deal, 1932-1940 (New York: Harper & Row, 1963), 56-58.

2.Hearings, May 1933, 25, 44, 51-52, 61.

3.In 1938, Harry Hopkins developed a plan for the WPA to do the construction associated with preparedness and rearmament. In an attempt to keep the work from going to the WPA, the Quartermaster Corps made an issue of who controlled emergency construction. By late 1938, President Roosevelt had come to favor the transfer of all military construction to the Corps of Engineers, if the transfer of responsibilities could be accomplished without a fight with Congress which might jeopardize his other programs. As part of these negotiations, the Corps agreed to have the WPA actually do, under the Corps' supervision, some of the construction associated with preparedness and rearmament. Since the May 1933 redefinition of the Upper Mississippi River 9-Foot Channel Project, relief workers employed by private contractors had already been building waterway improvement structures under Corps supervision. Since the Flood Control Act of 1936, the WPA had also been doing and funding flood control construction work under the supervision of the Corps. These precedents paved the way for the President's late 1938 decision to support the addition of the supervision of all WPA construction projects to the Corps' work load. Once he had made this decision, Roosevelt rapidly came to support the Corps' retention of all its traditional civil works functions. Roosevelt's reluctance to give all water resource development to the Corps revolved around the Corps' lack of experience in planning comprehensive programs. However, once Roosevelt had made his decision, it ended the 1920s and 1930s threat of removal of civil works functions from the Corps. Roosevelt to Senate, August 13, 1937, in Edgar B. Nixon, ed., Franklin D. Roosevelt and Conservation, 1911-1945 (Hyde Park, New York: General Services Administration, National Archives and Resources Service, Franklin D. Roosevelt Library, 1957), 102.

4.RG77, Entry 111, Boxes 977 and 978, File 3524, Washington National Records Center, Suitland, Maryland (hereafter referred to as WNRC); and transcript of Case No. 45051, Court of Claims of the United States, James Stewart Corp. vs. the United States (Lock 12), RG77, Entry 111, Box 673, WNRC (duplicate copy is in RG77, Entry 81, Box 678, NACB).

5.R.A. Wheeler to Chief of Engineers, November 13, 1933, and January 18, 1934, and E.L. Daley to Chief of Engineers, February 14, 1934, RG77, Entry 111, Box 990, File 3408, WNRC; R.A. Wheeler to Chief of Engineers, January 8, 1934, and March 19, 1934, RG77, Entry 111, Box 989, File 3344, WNRC; G.E. Edgerton to Chief of Engineers, October 22, 1934, and R.A. Wheeler to Chief of Engineers, January 7, 1935, RG77, Entry 111, Box 993, File 3524-part 1, WNRC; and transcript of Case No. 45262, Court of Claims of the United States, Maxon Construction Company vs. the United States (Lock 18), RG77, Entry 111, Box 685, WNRC.

6.Lieutenant Colonel Malcolm Elliot: Division Administrative Bulletin No. 1201, December 22, 1937, Subject: Kapok Vests (memorandum); R.L. Dean: Division Administrative Bulletin No. 1205.1, July 12, 1938, Subject: District Safety Regulations (memorandum); Schedule for UMVD Safety Meeting To Be Held In The St. Paul Minnesota District, June 22-23, 1939; Methods of Handling Visitors (memo, n.d., submitted by districts in compliance with request of this office dated May 11, 1937), RG77, subgroup: UMVD, Box 9, Para 5-C, SR 345-250-5, NAKCB; and Brian J. Kenny to Christine Whitacre, May 7, 1991, files of the Rocky Mountain Regional Office, National Park Service, Lakewood, Colorado.

7."Channel News," Old Man River 2, No. 5 (February 1938), RG77, St. Paul District, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

8.Dudley Hanson, Planning Division of the Rock Island District, to Christine Whitacre, April 25, 1991, files of the National Park Service, Rocky Mountain Regional Office, Lakewood, Colorado.

9.May 1933 Hearings, 53 and 71.

10.Annual Report 1933, 674; Annual Report 1934, 783; Annual Report 1936, 878; Annual Report 1938, 1047; Annual Report 1939, 1147; and Annual Report 1940, 1152. The prominence of the post-1933 division engineers is reflected in Col. Hodges's career. A 1905 West Point graduate, Hodges served with the 6th Engineering Division of the American Expeditionary Force in France. Between 1920 and 1923, he was district engineer for the Little Rock and Memphis districts. From 1928 to 1931, he was with the office of the chief of engineers in Washington, D.C. For the last two of those years, he was editor of the Military Engineer. Following his tenure with the UMVD, Hodges served in 1943 with the United States Army Forces, Middle East; and as division engineer for the North Atlantic Division (1943-44). He retired as a brigadier general in 1944 at the age of 60. He died at age 80 in 1965. George W. Cullem, Biographical Register of the Officers and Graduates of the U.S. Military Academy from 1802 to 1867 (rev. ed., with a supplement containing the Register of Graduates to Jan. 1, 1979, New York: James Mille, 1879), Entry 4351.

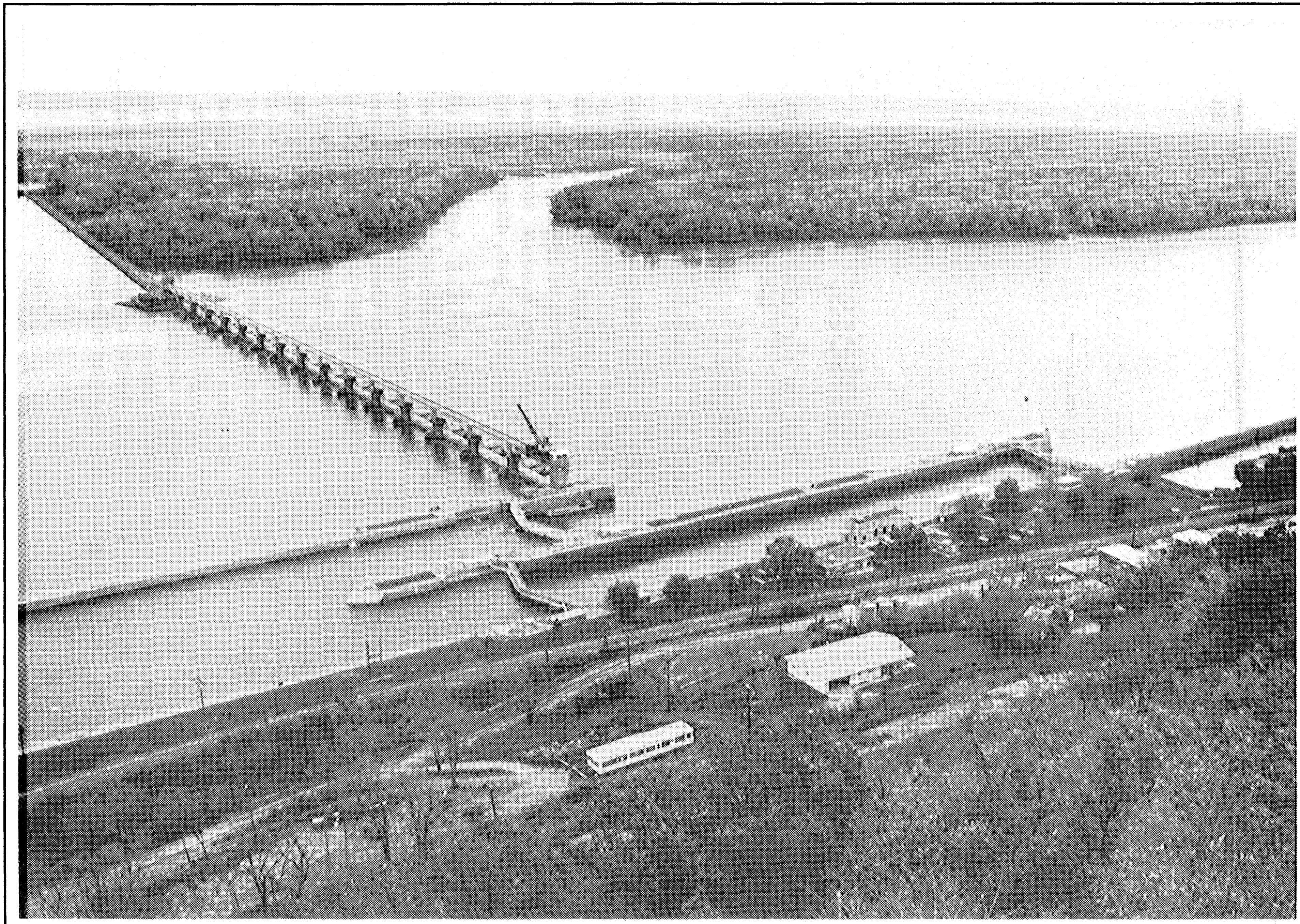
11.Leland R. Johnson to William Patrick O'Brien, February 6, 1988 (2nd letter of that date), copy in working files, National Park Service, Rocky Mountain Regional Office; "List of Officers and others available for Witnesses," February 4, 1937, RG77, Entry 111, Box 995, file 3524-part 3, WNRC; "List of Witnesses available to testify on Meltzer Claim Case on Lock 22," May 26, 1941, RG77, Box 998, file 3524, WNRC; Annual Report 1934, 783; Annual Report 1936, 878; Frederick J. Dobney, River Engineers of the Middle Mississippi: A History of the St. Louis District, U.S. Army Corps of Engineers (St. Louis: U.S. Army Corp of Engineers, St. Louis District, 1978), 92-93; Annual Report 1937, 916; and Annual Report 1938, 1047.

CHAPTER VII

From Rollers to Tainters: The Changing Technology of the 9-Foot Channel Project

All of the 9-foot channel installations along the Upper Mississippi River include observation decks. These decks offer scenic views of the river valley, as well as an opportunity to view the operations of the various lock and dam structures. And even the most casual observer of the 9-foot channel can see the differences between the dams, particularly between the dam gates. Some dam gates look like cylindrical tubes; others are pie-shaped wedges. While some dams have only one type of gate, others combine different systems.

During the course of the 9-Foot Channel Project, the U.S. Army Corps of Engineers developed technological innovations so quickly that, in some cases, structures were out-of-date almost as soon as they were built. Nowhere is this more evident than in the design of the dam gates. At the beginning of the 9-Foot Channel Project, Corps engineers designed dams that were equipped with non-submersible roller gates, then considered a state-of-the-art technology. These gates were soon followed by submersible roller gates that, in addition to having the capability of being raised, could also be lowered below the water's surface to allow for easier passage of ice and debris. During the project's middle stages, Corps engineers experimented with combination roller gate/Tainter gate dams. By the project's end, the Corps had designed new submersible and elliptical Tainter gate systems that made the combination gate systems obsolete. Indeed, the evolution of Tainter gate design is arguably the most significant technological development of the 9-Foot Channel Project. But it was not the only innovation. During the construction of the 9-foot channel on the Upper Mississippi River, the U.S. Army Corps of Engineers also generated innovations in construction



Lock and Dam No. 24, c. 1980. (U.S. Army Corps of Engineers, St. Louis District) techniques, foundation pilings, lock design, operating machinery, and a host of other technical details.

Thus, a unique construction document developed as the project progressed, imbedding itself into the concrete and steel of the 9-foot channel lock and dam system. From the beginning to the end, as Corps engineers designed and refined the technology of the 9-foot channel, those technological changes were manifested in the 9-Foot Channel Project's locks and dams. When viewed as a whole, the entire system affords a look at the dynamic evolution of American river engineering in the first half of the twentieth century.

The Locks and Dams of the 9-Foot Channel

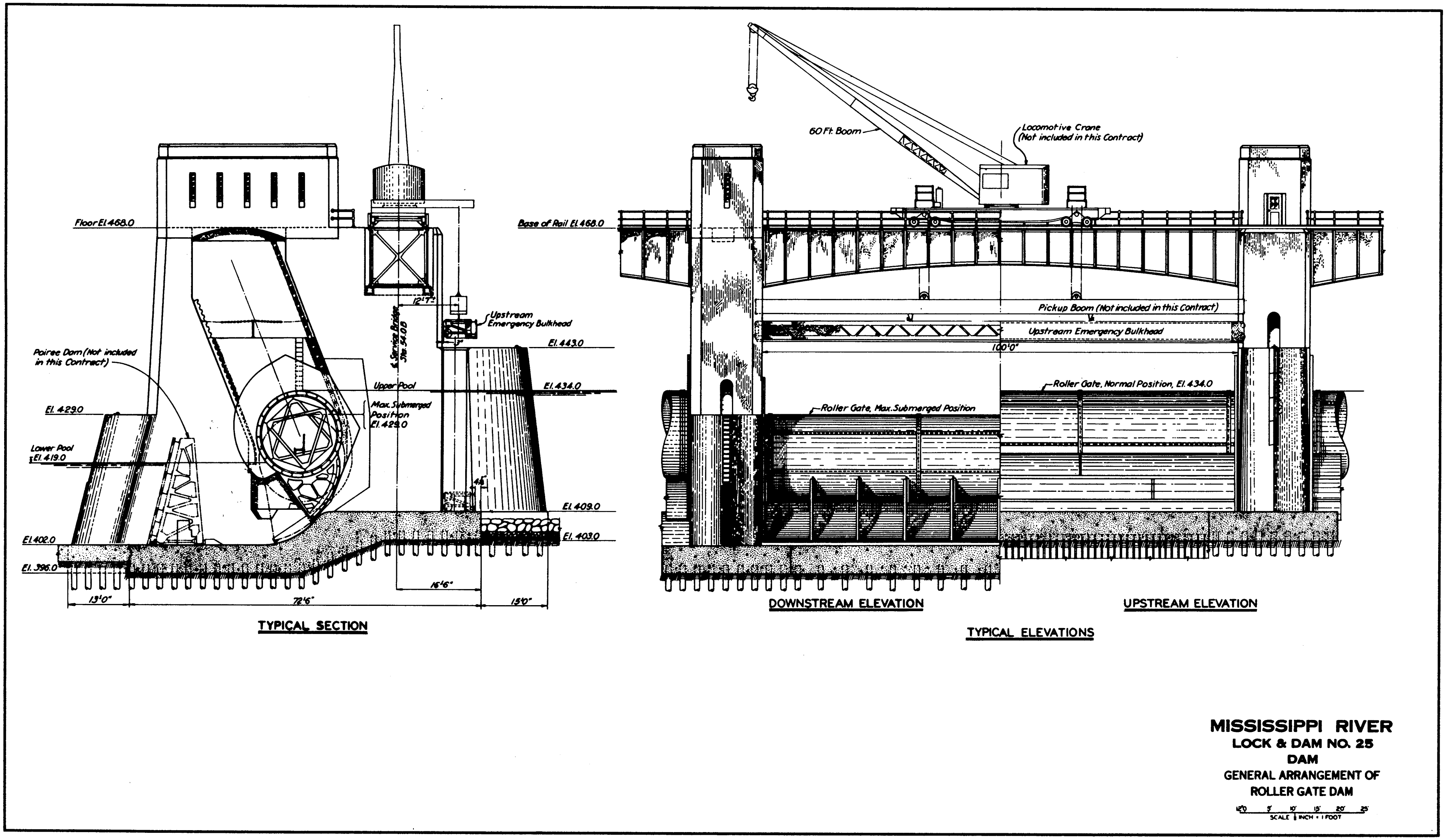
The Corps of Engineers typically designed each lock and dam complex in the 9-foot channel to include four basic components:

A non-navigable movable dam. Each dam holds back enough water to create a navigation pool, or slack-water lake, of a minimum 9-foot depth, while ensuring that the water level does not raise so high as to create flooding. The dams are "non-navigable" because vessels cannot navigate directly over them or through the dam gates; all river traffic must pass through the locks. The dams are "movable" because they have gates that are raised or lowered. Lockmasters adjust the flow of water through the gates. The Corps equipped each dam structure with roller and/or Tainter gates, as well as dikes, spillways, submersible dams, and other auxiliary installations.

Locks. Locks provide navigational access through the dam complex. Locks are the steps in the "aquatic staircase" of a lock and dam system, by which vessels are lifted or lowered from one pool to the next, while the pools themselves remain level. Corps engineers built the Upper Mississippi locks to standard dimensions of 110 feet wide and 600 feet long.

Foundations for future auxiliary locks. Most complexes include an auxiliary 100 by 269-foot lock. Although the auxiliary locks were seldom completed, the Corps always built the auxiliary lock foundations, equipping them with emergency gates. The foundations allow for future expansion. The Corps opens the gates of the auxiliary lock when the pool is drawn, allowing river traffic to pass.

Buildings and esplanades. The Corps built several buildings and structures at each complex site. These include lockmasters' and assistant lockmasters' dwellings, main control stations, stage recorder houses, garages, outbuildings, and various esplanades or greenspace.[1]



The first roller gates on the Upper Mississippi were non-submersible. Non-submersible gates are raised above the water's surface to allow the river to flow freely beneath them. Submersible roller gates are lowered beneath the water's surface, allowing the river to pass over them. Submersible roller gates were seen as an improvement over non-submersible gates because they allowed for the almost unobstructed flow of floodwater, ice, and debris. Dam No. 25 Construction Drawing, January 1937. (U.S. Army Corps of Engineers, St. Louis District)

Roller Gates

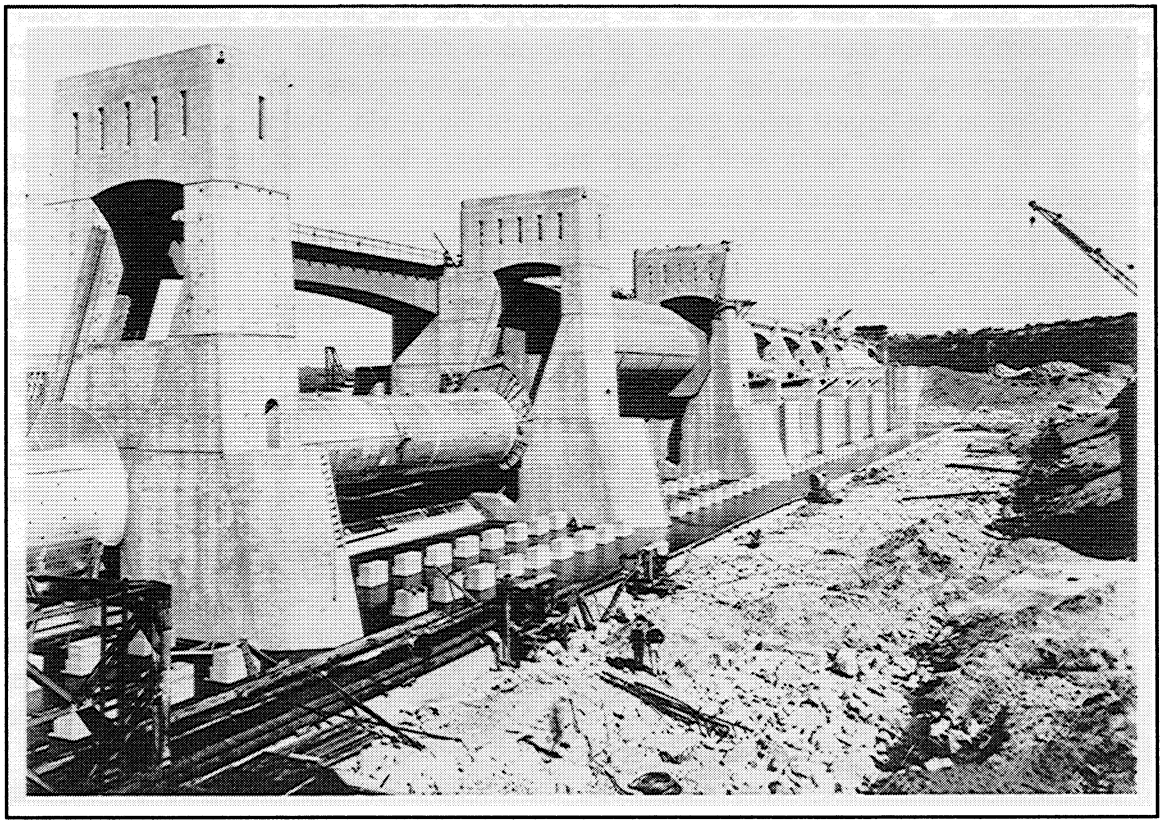
Lock and Dam No. 15, located near Rock Island, Illinois, was the first complex constructed as part of the Upper Mississippi River 9-Foot Channel Project, and its non-navigable roller gate dam served as the prototype for the project's subsequent roller-Tainter combination dams. The Corps of Engineers released the plans of the complex for public review in December 1930. When it was completed in March 1934, Dam No. 15 became the largest roller gate installation in the world. Individual gates had been built in Europe that were both larger and longer, but never had a single dam incorporated so many gates of such an aggregate length. With Dam No. 15, the Corps of Engineers developed construction methods and techniques that served as models for the remainder of the Upper Mississippi 9-Foot Channel Project.[2]

Dr. Max Karstanjen, director of the Maschinenfabrik Augsburg-Nurnberg (MAN) in Germany, had developed roller gates at the turn-of-the-century in Germany. European engineers, particularly those in the Scandinavian countries, adopted the design almost immediately. Two German companies, the Krupp Company and the MAN Company, controlled basic patents for the gate. By 1930, European engineers had been using roller gates in dams extensively for over 25 years. However, only 10 such structures had been built in the United States.[3]

When the Corps of Engineers decided to utilize roller gates on the Upper Mississippi River dams, that decision represented a massive commitment to a familiar technology in an unfamiliar context. However, the Corps refined and improved the design and operational characteristics of roller gates throughout the course of the Upper Mississippi River project. These innovations and improvements resulted in the development of a decidedly American style of submersible roller gate.

Still, American engineers understood the importance and influence of German engineering technology on the 9-Foot Channel Project. In a 1938 article published in The Military Engineer, Lieutenant Colonel P.S. Reinecke noted parallels between the Mississippi and the Rhine regarding commercial navigation. Reinecke delineated the similarities and differences in the two "regulated river" projects, including the advances made in American technology. He concluded his article on a positive economic note: "After considering the example of the Rhine . . . it is reasonable to forecast a highly successful and satisfactory development of navigation along the Upper Mississippi in a few years."[4]

Simply defined, a roller gate is a cylindrical, metal tube that lays across the water between two concrete piers. The first roller gates on the Upper Mississippi were non-submersible. When lowered, a non-submersible roller gate rests directly on the dam's concrete sill, holding back the water. When raised, the roller gate allows water to flow freely beneath it. A single dam can have several roller gates, each of which can be operated independently. Each gate raises and lowers by means of a multiple, side-bar chain mechanism, similar to an enormous bicycle chain. The solid ends of each roller gate are fitted with sprockets, which engage inclined racks attached to the piers. As an electric motor housed within one of the piers hauls in the chain, the gate moves slowly up the racks. Only one end of the drum is driven, the other end merely rides up the racks.[5]

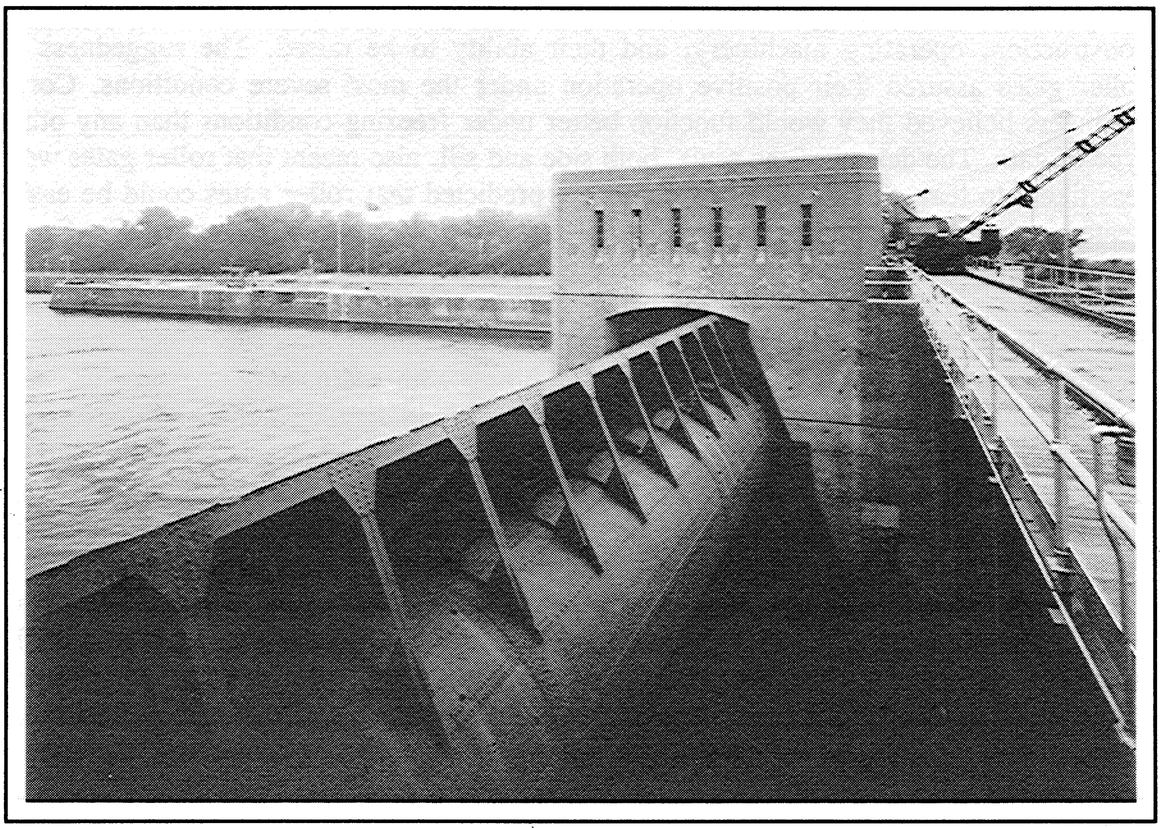


Construction of Dam No. 25, October 1938. The concrete baffles help dissipate the energy of the water passing over the spillway. (U.S. Army Corps of Engineers, St. Louis District)

A roller gate's trussed cylinder provides strength, and makes the gate very rigid along its longitudinal axis. An early improvement to the basic design was the attachment of a curved steel apron to the lower side of the gate, which reduced the required drum diameter and permitted use of a waterproof timber or rubber seal. The ends of a roller gate are equipped with flexible steel shields, the linings of which fit the slightly inclined planes of the faces of the piers. Water pressure keeps the end shields tight against the piers.[6]

The first roller gates in the United States were used on flood control and irrigation projects. In 1914, the Washington Water Power Company used three roller gates for spillway crest control at a dam located on Long Lake near Spokane, Washington. Each of these gates was 65 feet long. In 1916, the U.S. Bureau of Reclamation Service utilized seven roller gates, measuring up to 15 by 70 feet, in an irrigation dam located on the Grand River near Palisade, Colorado.[7]

With the Grand Valley Diversion Dam near Palisade, Colorado, Reclamation Service engineers established the basic form for American roller gate dams. As a result of this project, Reclamation Service engineers also gained considerable experience in the fabrication and erection of roller gates. The outbreak of World War I in Europe prohibited the German patent holder, the MAN Company, from completing the design and fabrication of the gates. As a result, Frank Teichman, an engineer for the Reclamation Service, hurriedly reworked the German plans, and the Riter-Conley Manufacturing Company of Pittsburgh fabricated the gates. Elevations and sections of the Grand Valley Diversion Dam show the basic form of the piers and fixed service bridge to be the same as those in Dam No. 15 of the Upper Mississippi River 9-Foot Channel Project. The architectural style of the Grand River dam's piers are also clearly direct precursors of Dam No. 15's roller gate piers.[8]



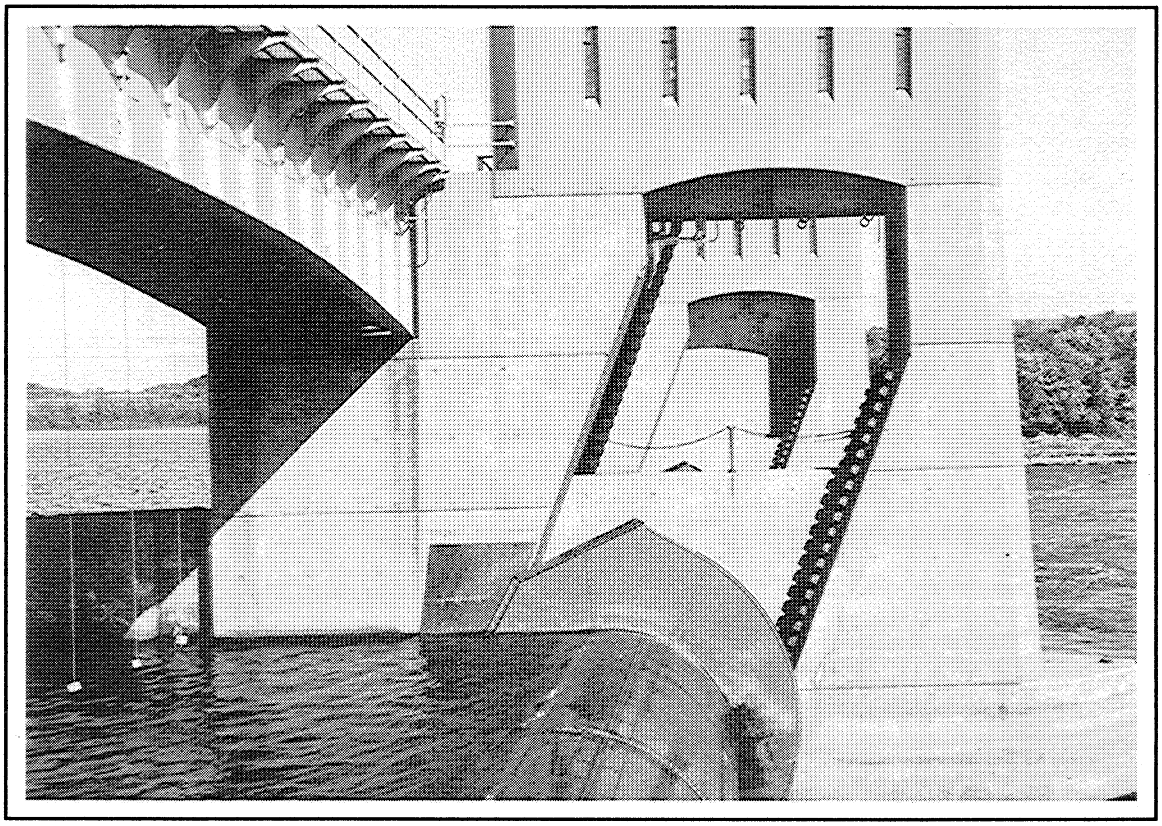
An early improvement to roller gate design was the attachment of a curved steel apron to the side of the gate, which reduced the required drum diameter and formed a more reliable and waterproof seal. Dam No. 5A. (Clayton B. Fraser, Fraserdesign)

Upper Mississippi Valley Division Head Engineer William McAlpine and the design team of the 9-Foot Channel Project chose to include roller gates in that project's dams for a variety of reasons. The Corps engineers had their choice of several types of movable crest gates: vertical lift gates, Tainter gates, sector gates, and roller gates. But roller gates had several advantages. The inherent strength of roller gate drums permitted construction of long gates with an economic use of metal. At the time, roller gates could also be built at lengths greater than any of the other types of movable gates suitable for pier dams. Corps engineers knew that these greater lengths would allow maximum clear openings through which to pass running ice, drift, and flood waters. The longer lengths would also reduce the number of dam piers, which also served as obstacles. The Corps wanted to achieve the freest flow possible on the Upper Mississippi River. Winter ice gorges posed a serious threat not only to the dams, but also to private property along the riverbank. In the spring, the river's flood waters carried heavy drift. The 9-Foot Channel Project engineers understood the necessity of passing the maximum amount of flood water quickly because the Upper Mississippi's banks were low, the bottoms densely farmed, and towns and railroads were located close to the river.[9]

The Corps of Engineers also selected roller gates because of the gates' massive construction, operating machinery, and their ability to be raised. The ruggedness of roller gates assured their positive operation under the most severe conditions. Corps engineers believed they would function better under freezing conditions than any other type of gate. The design of the seals, both side and sill, also meant that roller gates were less likely to leak. In addition, the engineers predicted that roller gates could be easily heated in freezing weather. (Unfortunately, this did not prove to be the case.) The Corps also preferred roller gates because of their ability to be raised above the water. The engineers were leery of submersible gates, such as some types of sector gates, because they were concerned about excavating the riverbed into which the gates would be lowered. They expected these excavations to fill up with sediment.[10]

By 1933, however, the 9-Foot Channel Project engineers had changed their minds about submersible gates. Construction of Dam No. 15 began in February 1932, and by 1933 enough gates were in operation for the engineers to learn that floating ice could not pass underneath the gates unless they were raised approximately half the distance from the sills to the surface of the upper pools. To open the gates this far during freezing temperatures, when the Upper Mississippi is usually low, lowered the upper pool below the desired level. This practice adversely affected the natural habitat of the area, and created scour problems below the dam apron and stilling basin. Opening the gates so wide also produced a very concentrated flow and caused serious erosion on dams with sand foundations. As a result, project engineers reconsidered the use of submersible roller gates that would allow ice, debris, and flood waters to pass over, rather than under, the gates.[11]

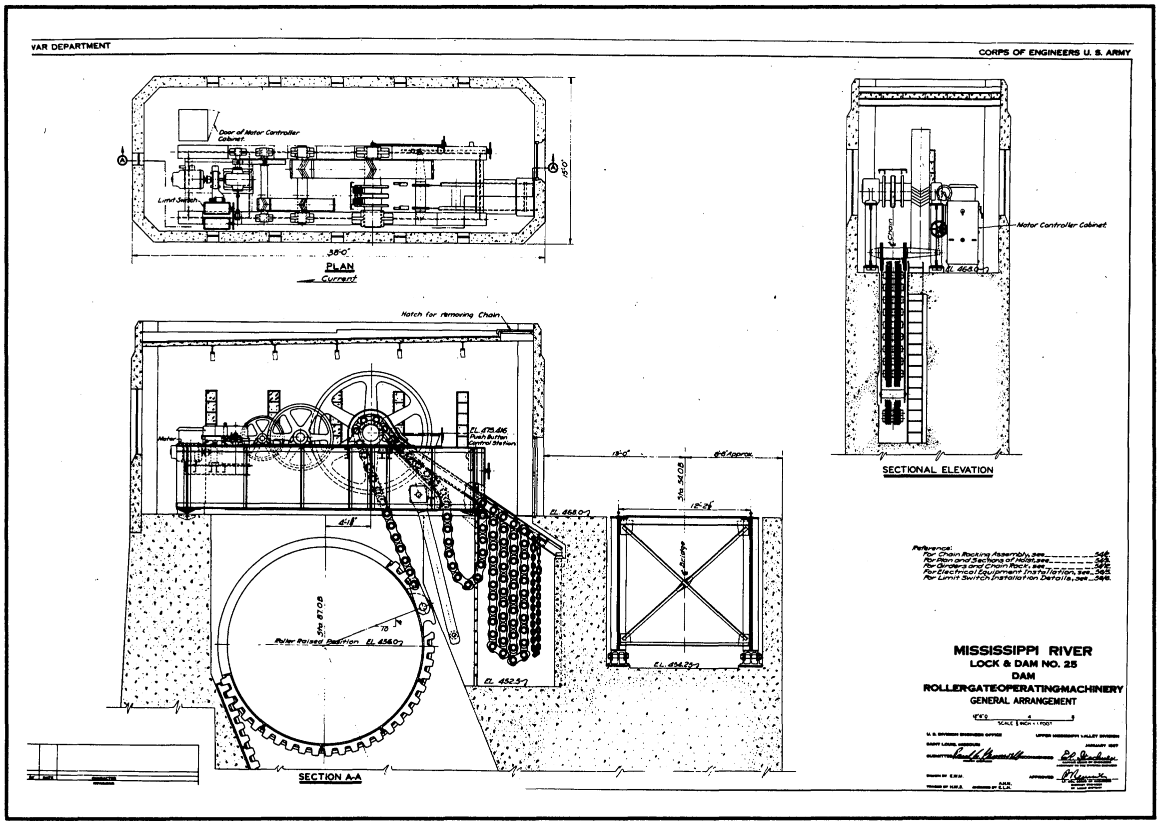
Almost simultaneously with its work on Dam No. 15, the Corps of Engineers was designing roller gate dams on the Kanawha River, a West Virginia tributary of the Ohio River. On the Kanawha River, Corps engineers specified that one of the dam gates be fully submersible. Dravo Contracting of Pittsburgh, the gate contractor, proposed instead to fabricate a gate with a movable flap hinged to the top of the drum. This flap could be lowered onto the face of the drum, providing a 5-foot overflow atop the gate. Although this innovation was not widely used in subsequent Corps of Engineers' roller gate dams, it pointed the way towards the use of submersible gates, the most significant innovation in roller gate design to emerge from the 9-Foot Channel Project. Corps engineers refined and improved the design and operation of roller gates throughout the course of the Upper Mississippi River project. These innovations resulted in the development of a decidedly American-style submersible roller gate.[12]



Roller Gate Pier and Operating Machinery House. Dam No. 25. (John P. Herr, John Herr Photography)

The Corps of Engineers first used submersible roller gates on the Upper Mississippi River at Dam No. 4, located in the St. Paul District. The Corps began constructing Dam No. 4 in November 1933. The submersible roller gates of Dam No. 4 submerge to a depth of 3 feet. At other dams in the St. Paul District, such as Nos. 3 and 9, Corps engineers installed gates that submerge approximately 5 feet, so that heavy loads of ice could easily pass over them.

Rock Island District staff made many of the design modifications relating to submersible roller gates. The construction of Dam No. 15 within that district had demonstrated the problems associated with non-submersible gates. Although Dams Nos. 20 and 16, which were designed in August 1933 and September 1934, were equipped with the original, German-designed, non-submersible roller gates, the district design team soon modified this basic design.



A roller gate is raised and lowered by a multiple side-bar chain similar, on an enormous scale, to a bicycle chain. Dam No. 25, Roller Gate Operating Machinery Construction Drawing, January 1937. (U.S. Army Corps of Engineers, St. Louis District)

District engineers designed their first submersible roller gates in 1935 for Dams Nos. 11 and 18. A non-submersible roller gate had only one sill level; the gate lowered against the sill to form a bottom seal. But the new submersible roller gate had two sill levels: a higher upstream level and a lower downstream level, which were joined by a curved section of concrete. The Corps designed the submersible roller gate to either rest next to the higher level of the sill--to form a bottom seal--or slide along the curved section of concrete until it reached the lower level. At the lower level, the gates at Dams

Nos. 11 and 18 are 8 feet below their normal closed position.

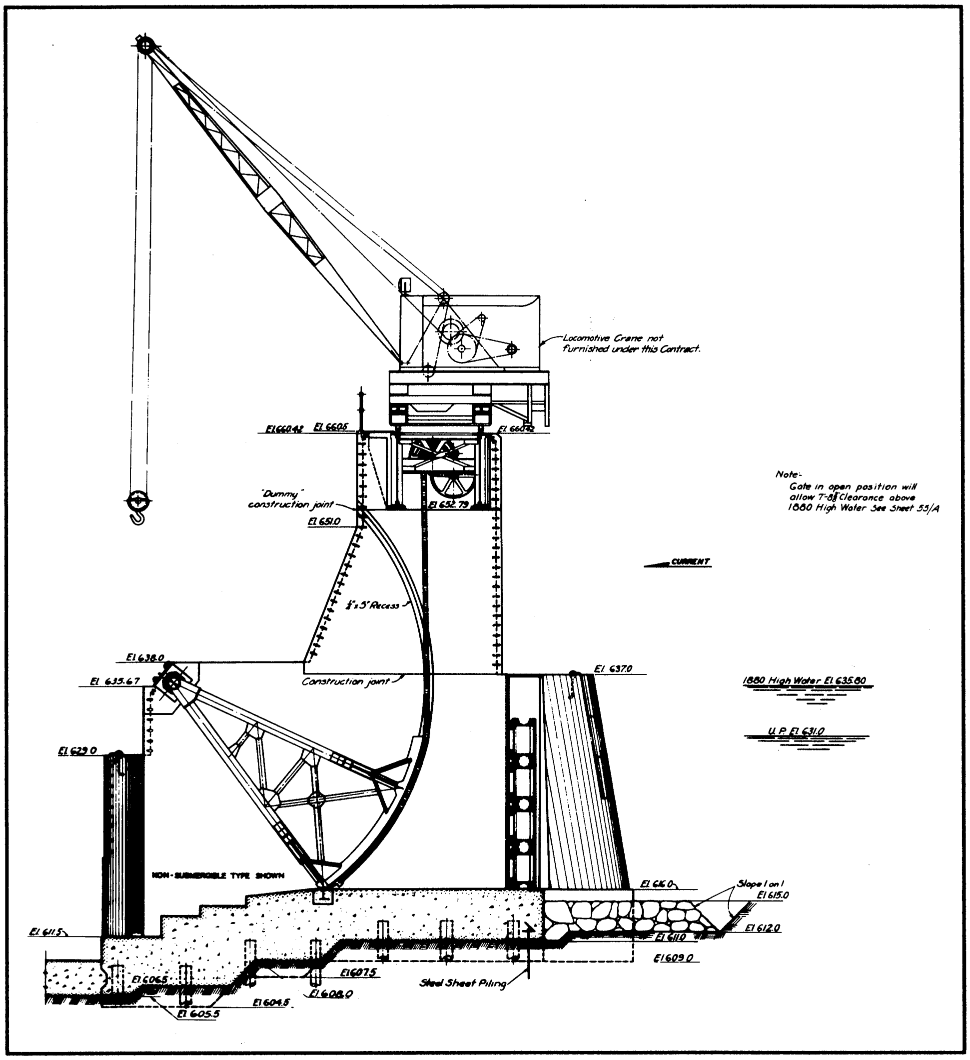
The new submersible roller gates did not totally solve the scour or water elevation problems of the upper pool that had manifested themselves at Dam No. 15. As a result, Corps engineers attempted to mitigate these problems by reducing the depth to which the gates submerged. The roller gates in Dam No. 21 were designed to submerge to a depth of 4.67 feet, but engineers were still dissatisfied. In 1936, the Corps designed roller gates for Dam No. 22 that submerged 8 feet. In this design, the engineers also incorporated a Poiree dam trestle the same height as the downstream fender on the adjoining piers. The Corps set the dam trestles immediately downstream from the downstream level of the sills. As a result, the trestle units acted as weirs. In 1937, the Corps hired the Worden-Allen Company of Milwaukee to furnish enough Poiree dam trestles to retrofit the dams in all three districts built prior to Dam No. 22. Still, the Rock Island District was not happy enough with this solution to include it in its new designs. For its last three dams, Nos. 13, 14, and 17, the district engineers once again reduced the submersible depth to 4.67 feet.[13]

Corps officials were in constant communication with the companies that manufactured the roller gates. Companies such as the Allis-Chalmers Company of Milwaukee, the M.H. Treadwell Company of New York, and the McClintic Marshall Corporation of Chicago were included in the continuing dialogue involving every possible detail of roller gate design. The first indication of a problem triggered a flurry of correspondence between the Corps and private engineers to find solutions. Typical problems involved such items as discrepancies in interior bracing in the drum assemblies, end shield adjustments, and 10-degree changes in pressure angle designs for rack and spur rim teeth. The Corps of Engineers had to accurately resolve these and countless other details on a day-to-day basis in order for the leviathan project to proceed.[14]

Tainter Gates

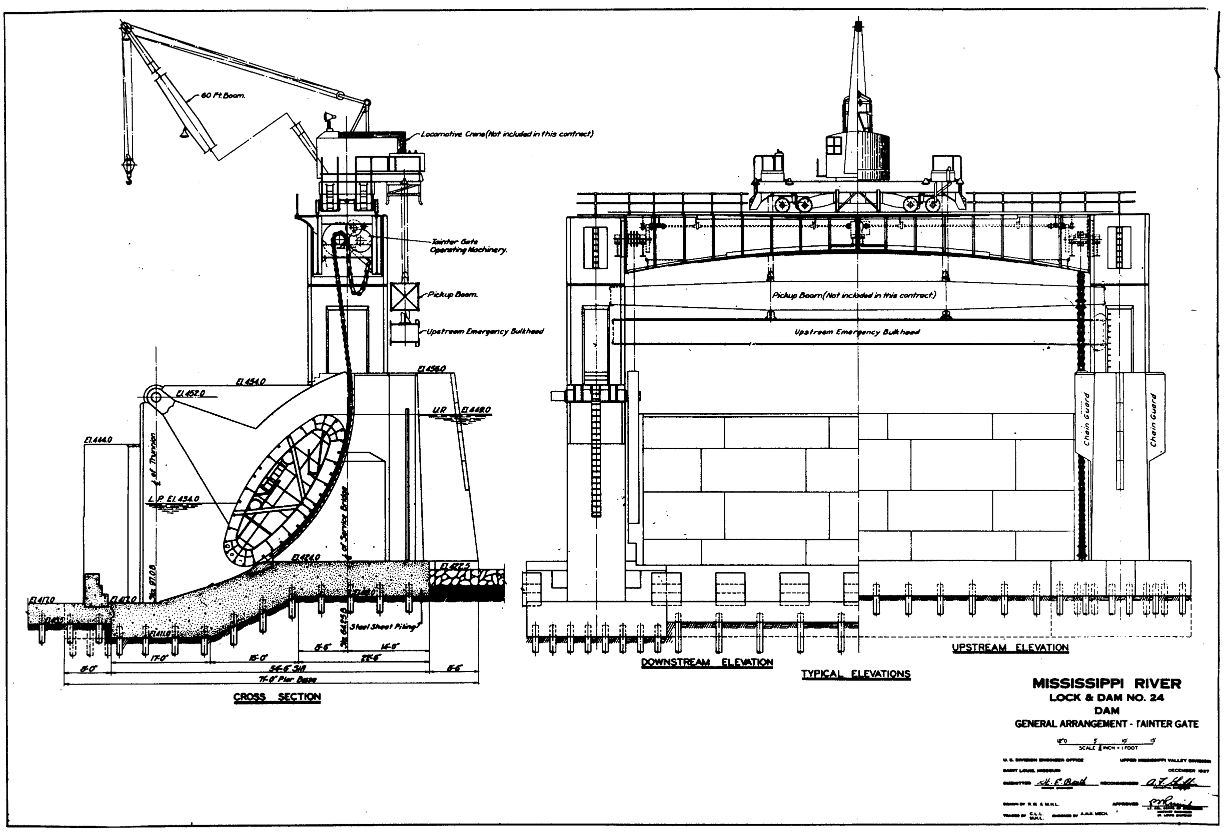
While roller gates attracted the greatest attention in the national civil engineering journals, most of the gates used in the 9-Foot Channel Project were Tainter gates. By the end of the project, the U.S. Army Corps of Engineers had developed Tainter gates that were so advanced that they made roller gates obsolete. Indeed, Tainter gate design developed so rapidly that one Corps officer commented that "the first dam of a series may be partially out-of-fashion by the time the last one is built."[15]

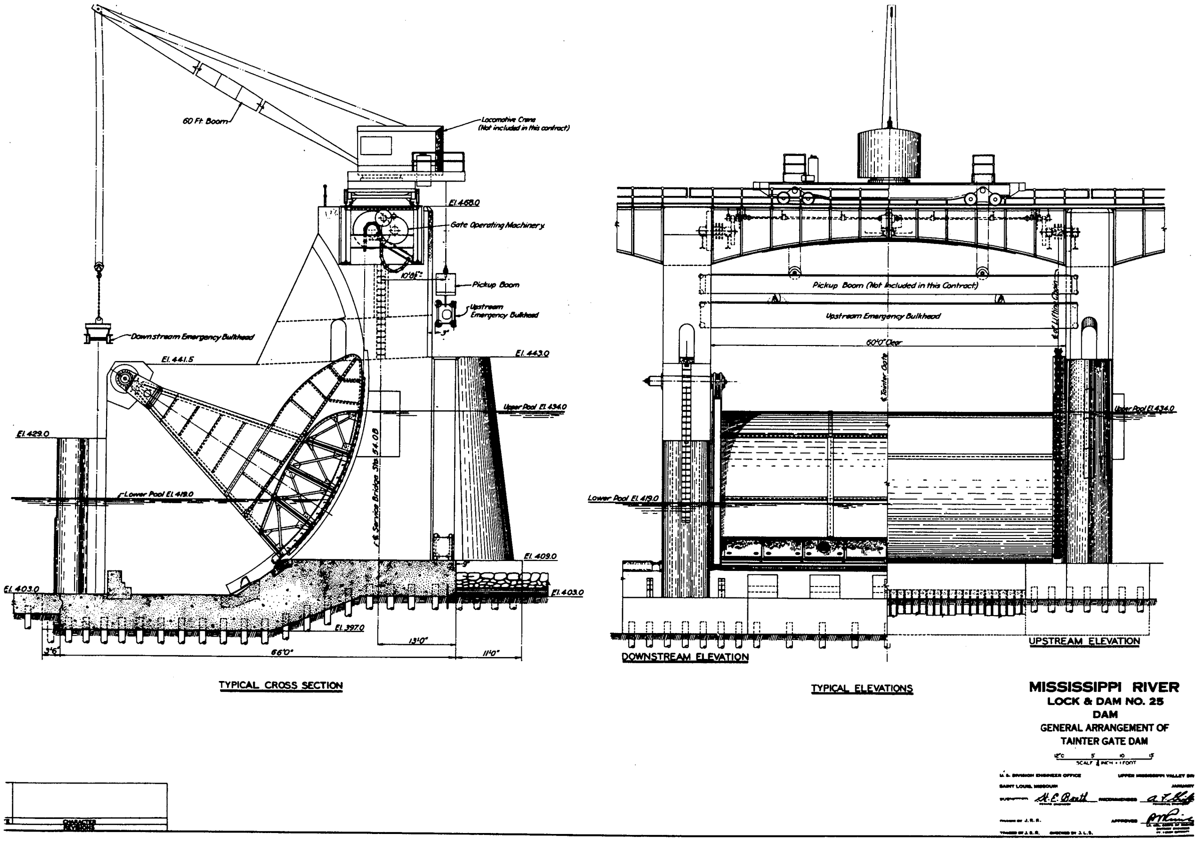
Viewed from the side, a Tainter gate and its armature look like a pie-shaped wedge: a lengthwise segment of cylinder with triangular arms extending from each end. The cylindrical section of the gate forms the damming surface. While a roller gate is lifted up and down, the arms of a Tainter gate pivot on pins attached to the supporting piers. The Corps of Engineers opened and closed the first Tainter gates on the Upper Mississippi River by means of a cable or chain attached to the lower side of the gate shield and driven by machinery located above the gate on the dam's service bridge. The

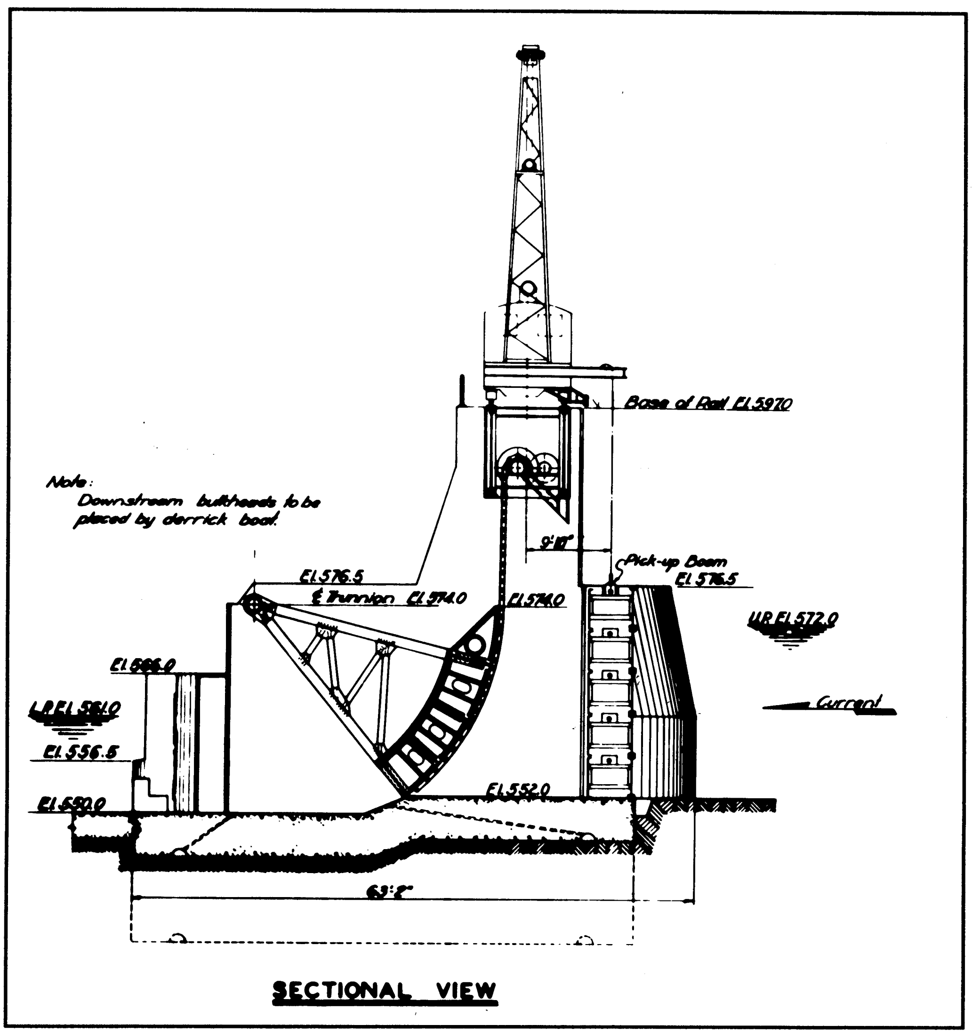


In cross-section, a Tainter gate and its armature resemble a pie-shaped wedge. From the smaller end, triangular arms extend toward the wider, water-side face of the gate. Like this gate on Dam No. 8, the first Tainter gates used on the 9-Foot Channel were non-submersible. Dam No. 8 Construction Drawing, June 1935. (U.S. Army Corps of Engineers, St. Paul District)

(Below) The Corps of Engineers continually refined Tainter gate design throughout the 9-Foot Channel Project. The submersible Tainter gates on Dam No. 24 are elliptical; steel skin plates totally surround a steel truss frame. The streamlined shell protects the gate's framework from ice and debris, and provides a smooth surface for the water. Dam No. 24 Construction Drawing, December 1937. (U.S. Army Corps of Engineers, St. Louis District)







(Above) The Corps also experimented with a truncated form of submersible elliptical gate. Dam No. 25 Construction Drawing, January 1937. (U.S. Army Corps of Engineers, St. Louis District)

(Left) Arch-shaped, non-submersible gates were used at Dam No. 14, where the river bedrock made it very expensive to build submersible gates. Like the elliptical gates, arch-shaped gates are encased in steel siding. Dam No. 14 Construction Drawing, August 1936. (U.S. Army Corps of Engineers, Rock Island District)

shape of the gate was such that the water pressure behind the gate had little effect, and the hoist machinery merely had to overcome the deadweight of the gate. By the end of the project, Corps engineers had eliminated the hoisting method in favor of a system operated by a line shaft and motors.[16]

North American hydraulic engineers had been using radial gates based on the same principles as the Tainter gate for over 100 years by the time the Upper Mississippi design team began incorporating them into its designs. Tainter gates are of American origin. As early as 1827, when Captain Marshall Lewis applied for a patent on his semi-circular, cast-iron gate turning on pivots connected to the gate by arms, he admitted he had not designed a new gate type but merely made some important improvements in what was already known as the "common paddle gate."

Refinements in Tainter gate design continued throughout the nineteenth century. In 1840 and 1841, George W. Hildreth of Lockport, New York, and George Heath of Little Falls, New York, patented such similar refinements in the design that a series of court cases and state legislative actions ensued. By 1853, the noted French hydraulic engineer Poiree had adapted a similar segmental arc gate for use in movable dams. Wisconsin lumberman Theodore Parker made further refinements in the basic design. Parker sold his rights to Jeremiah Burnham Tainter who patented the gate system in 1886. In 1889, Major William L. Marshall became the first Corps officer to use Tainter gates, adopting a manually-operated version of them for use on a movable dam across the Rock River between Rock Falls and Sterling, Illinois.[17]

Tainter gates are economical and simple to fabricate, erect, and operate. But there was still room for improvement when the UMVD design team began assimilating them into its Upper Mississippi River designs in 1932 and 1933. At first, Corps engineers considered Tainter gates too small and too unreliable, in terms of their operation under adverse conditions, to be used in the principal spillway sections of the dams. In addition, most American Tainter gates averaged 30 to 35 feet in length. Given the Corps' requirements for a 100-foot gate that operated reliably under all kinds of conditions, Corps engineers initially designed the main section of the dam with roller gates, and completed the movable portion with a series of Tainter gates. The engineers had discovered that three or four 100-foot-long roller gates situated in the thread of the stream were all that were necessary to pass ice, drift, and flood waters satisfactorily.[18]

Initially, the Corps of Engineers believed the combination roller and Tainter gate dam was ideally suited to the particular needs of the 9-Foot Channel Project. However, many contemporary experts in the field of movable dam construction believed that dams should never employ more than one type of gate. In his 1937 work, Hydraulic Structures, Armin Schoklitsch argued that "water level[s] can be regulated and the debris deposits sluiced out more effectively if all the regulators [gates] are alike . . ." The decision to use more than one type of gate in any dam was, according to Schoklitsch, "essentially a matter of cost." The U.S. Army Corps of Engineers, however, adopted the combination gate for the same reason that Schoklitsch advised against it--to accommodate the need for an exact regulation of flood stage variables. Again, the Upper

Mississippi dictated a change in engineering philosophies.[19]

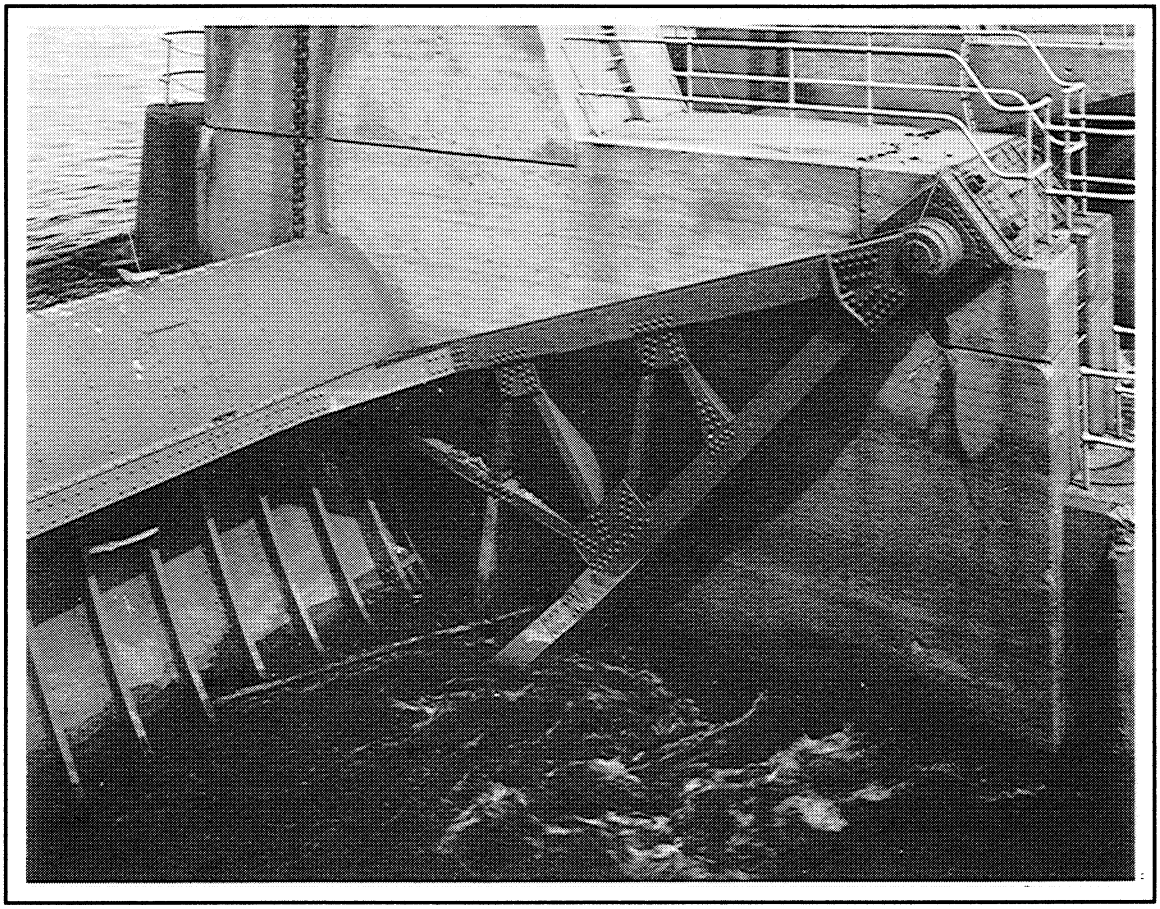
During the 9-Foot Channel Project, the Corps developed several innovations in Tainter gate design. Prior to the project, engineers believed that Tainter gates, like the original German-designed roller gates, should be raised above the water rather than submerged. However, the Corps' work in developing submersible roller gates eventually resulted in the design of a submersible Tainter gate. Corps engineers designed many of the 9-Foot Channel dams, such as Nos. 20 and 16, to include both submersible and non-submersible Tainter gates. The earliest form of a non-submersible Tainter gate was comprised of a drum-type gate with steel skin plates on the curved water-side face. The water-side face of the submersible gate was identical to that of the non-submersible gate. However, Corps engineers modified the submersible gate to include an additional overflow plate that arched back downstream from the top of the gate face.

In May 1935, Corps engineers initiated a new kind of submersible Tainter gate at Dam No. 18, located in the Rock Island District. On this new gate, steel skin plates totally surrounded a steel truss frame. The Corps designed the gate to be the shape of a three-quarter ellipse; the back of the gate face was convex rather than concave. The streamlined steel shell of this new gate protected the gate's steel framework from ice damage, and provided a smooth unobstructed surface for the water that passed over the gate in its submerged position.

The 9-Foot Channel Project engineers had conducted model studies that indicated that the earlier, drum-type gates created "a negative pressure on the crest that may cause vibration and excessive fatigue, or corrosion of the metal." Manufacturers, however, found the new, elliptical-shaped gates to be difficult and expensive to build, and the truss framing required the distortion of certain connection angles. As a result, Corps engineers revised the framing, substituting a girder frame for the truss frame. Dam No. 11 was the first representation of this more sophisticated, elliptical, Tainter gate design.

Despite scour problems, Rock Island District engineers incorporated the elliptical Tainter gate into the five dams founded on sand that they designed after Dam No. 18. The engineers also continued to test new designs. At Dam No. 22, district engineers added elliptical shields to both ends of that dam's one submersible Tainter gate. When the gate was submerged, the shields prevented water from seeping between the gate and the piers. The Corps followed up on this experiment. In 1939, the Corps' Hydraulic Laboratory at Iowa City made 19 models of Dam No. 22's submersible gate, and conducted 157 tests on them in order to develop a satisfactory stilling basin for submersible Tainters, as well as a design for improved Tainter gate hoisting machinery and operation.[20]

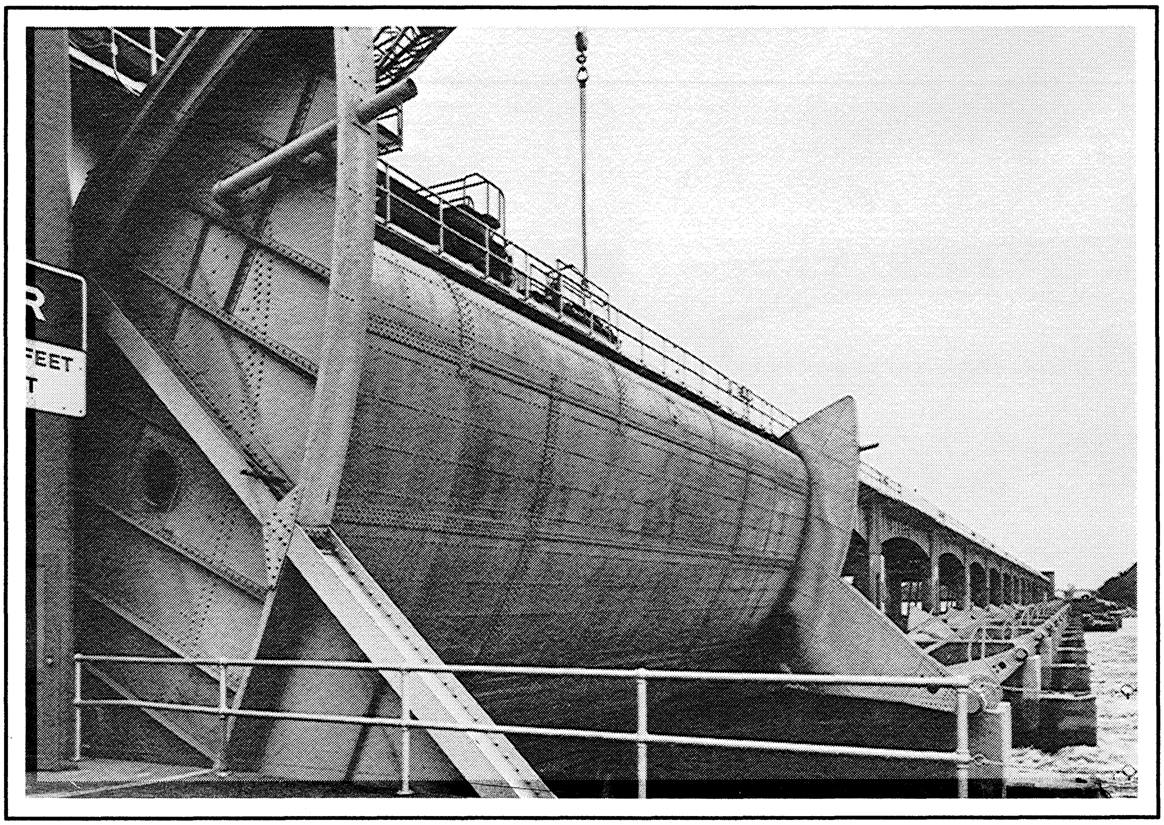
At Dam No. 22, the Corps of Engineers also introduced a new type of non-submersible Tainter gate. Like the submersible elliptical gate, the new non-submersible gate was totally surrounded by steel siding. But, rather than being elliptical, the gate was arch-shaped, similar to the non-submersible Tainter gates that had metal sheathing only on one side. The Corps apparently wanted the improved longitudinal rigidity, increased strength, and ruggedness of the elliptical Tainter gate but did not need, at a dam founded on bedrock, the scour diminution offered by the submersible gate. Also, because of the bedrock foundation, it would have been very expensive for the Corps to have constructed the two-level sills necessary for submersible gates. The Rock Island District used these new, non-submersible, Tainter gates exclusively in Dam No. 14, which was also founded in bedrock.



The first form of Tainter gates used on the 9-foot channel had steel plating only on the water-side face of the gate. A submersible gate, such as this one on Dam No. 8, can be distinguished by the additional overflow plate on the top of the gate, which provides a streamlined surface for breaking through the water. Dam No. 8, Submersible Tainter Gate. (Clayton B. Fraser, Fraserdesign)

Submersible elliptical Tainter gates and non-submersible arched Tainter gates supported the construction of gates at unprecedented lengths. Corps engineers were soon building Tainter gates at lengths of 60 feet. Eventually, Dam No. 24, located in the St. Louis District, employed Tainter gates that were 80 feet long.

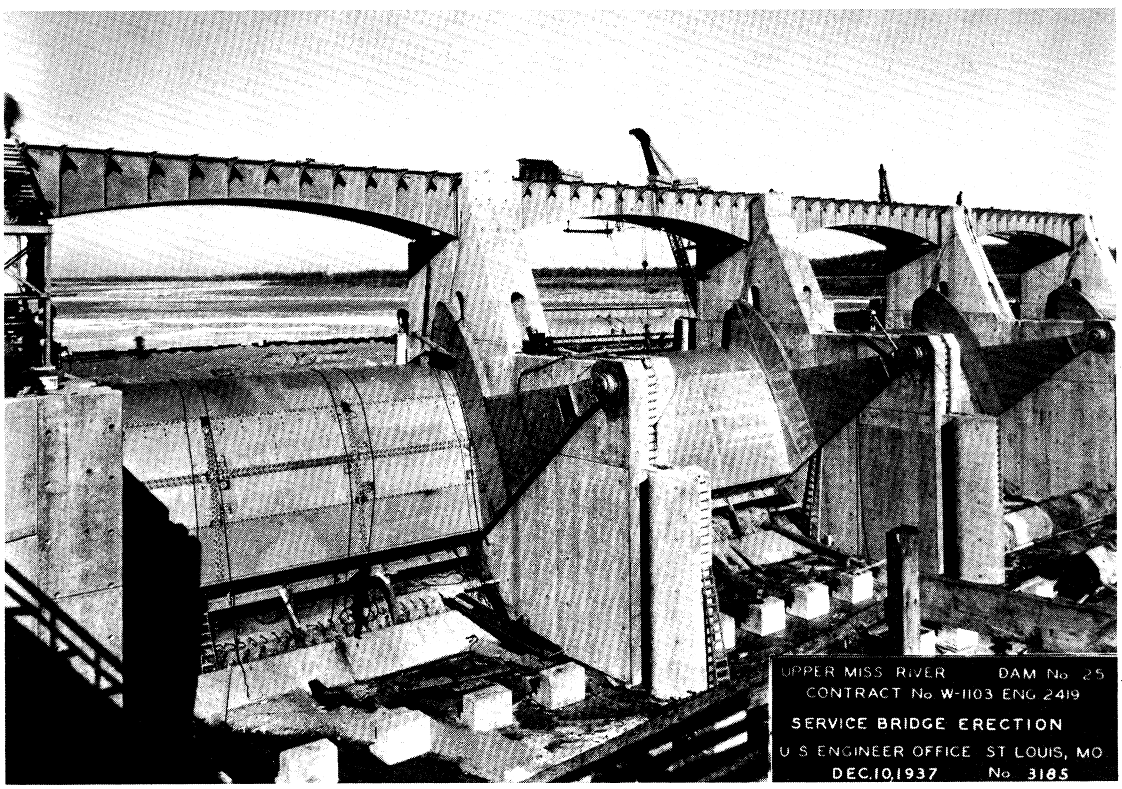
The Corps of Engineers designed Dam No. 24 in December 1937. With this dam, constructed in 1938-1939, the Corps attained its highest level of Tainter gate technology during the 9-Foot Channel Project. Corps engineers incorporated fifteen 80-foot-long Tainter gates into the 1,340-foot long movable portion of Dam No. 24. The large size of these gates, and the relatively ice-free conditions that characterize this stretch of the Upper Mississippi, convinced Corps engineers to entirely eliminate roller gates from this dam. At the time of construction, the Corps believed the Tainter gates at Dam No. 24 to be the largest ever constructed.[21]



Dam No. 24, Submersible Elliptical Tainter Gate. The shields on the ends of the gate prevent water from seeping between the gate and the piers. Typical of later gate designs, the gate armature on Dam No. 24 is solid. Earlier designs, such as Dam No. 8 pictured on the opposite page, featured open framework. (John P. Herr, John Herr Photography)

The Corps designed the Tainter gates at Dam No. 24 to be fully submersible and elliptical in section. Project engineers selected the elliptical design because it permitted the shell of the gate to act as a beam between the end supports, eliminating the need for extensive internal bracing and framework. The design also reduced both the quantity of steel required to fabricate the gate and its operational weight. An additional reduction in weight, as well as an improvement in corrosion resistance, resulted from the use of high tensile, phosphorous chromium steel for most movable portions of the gates.

Dam No. 24 represented a vast improvement in Tainter gate design. Within the space of just a few years, the Corps had improved the design of Tainter gates so dramatically that roller gates, the principal engineering feature discussed in early technical articles related to the 9-Foot Channel Project, were entirely superseded by a cheaper, simpler, and more reliable gate type. These developments made roller gate technology obsolete, effectively bringing to an end the short history of combination roller-Tainter gate dam construction in America.



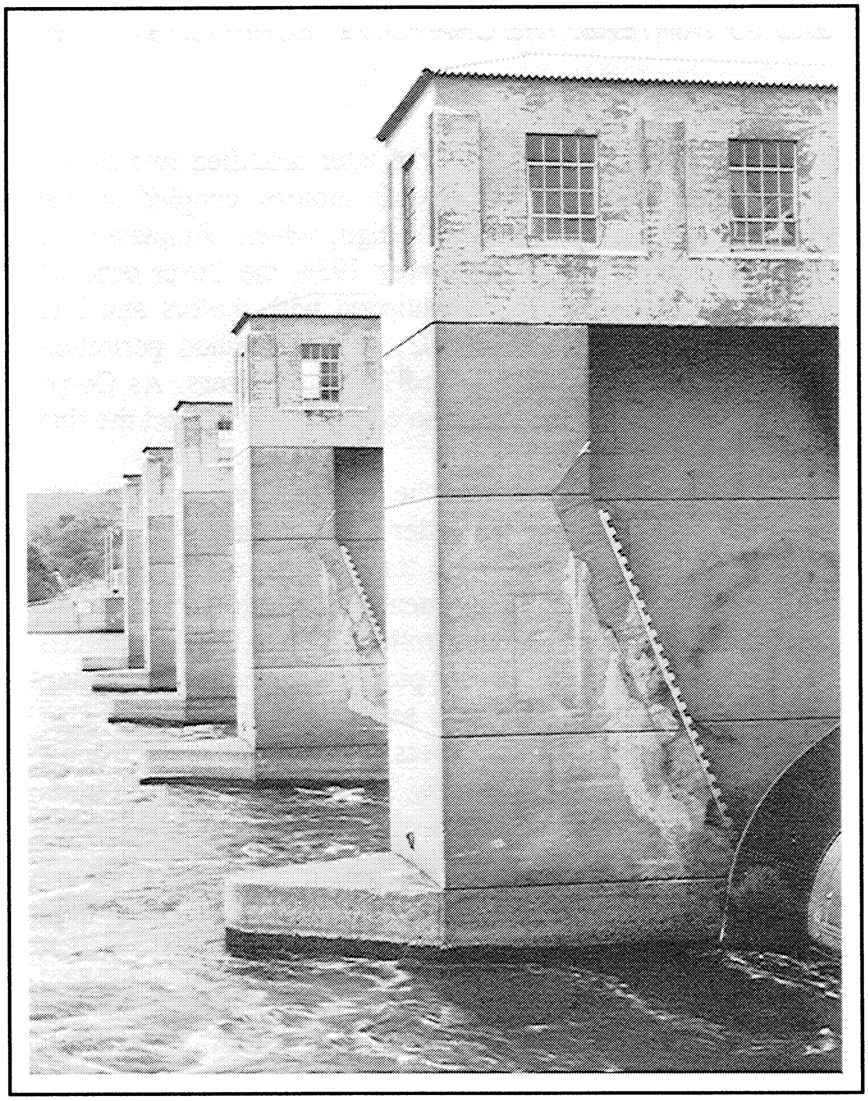
The construction of Dam No. 25, which has truncated elliptical Tainter gates, December 1937. (U.S. Army Corps of Engineers, St. Louis District)

The Corps' methods of operating Tainter gates also evolved significantly during the Upper Mississippi River 9-Foot Channel Project. Rock Island engineers originally designed all 40 Tainter gates in Dam No. 20 to be hoisted by locomotive cars running on the dam's service bridge. As an experiment, the district later modified two of the Tainter gates so that they were hoisted by individual electric motors, coupled to line shafts, housed in installations above each gate. The new design, which eliminated the need for the locomotive cars, was a success. After September 1934, the Corps ordered all new Tainter gates on the Upper Mississippi to be equipped with motors and line shafts. Although more expensive to construct and install, the new method permitted rapid, simultaneous operation of several gates and required fewer operators. As Corps engineers continued to modify Tainter gate design, they also continued to perfect the line shaft and motor assemblies.[22]

The 9-Foot Channel Project engineers also refined the auxiliary parts of the gate systems. After using the emergency bulkheads for the roller gates at Dam No. 15, the Corps realized that considerable silt accumulated inside these units, increasing their weight and making them more expensive to clean. Consequently, the engineers modified the bulkhead units to provide for end guide and reaction rollers, buffer blocks, molded rubber end seals, more efficient curb plate splices, a better pickup device, and projecting angles in the bulkhead recesses against which the end seals bear. The Corps also improved the Tainter gate emergency bulkheads. Engineers replaced the welded units with riveted units, reducing the number and cost. The new Tainter gate bulkhead units were also stiffer and more stable, and hazards due to defective welding were reduced. The Rock Island District first used these modified roller gate and Tainter gate bulkheads at Dams Nos. 11 and 18, and they soon became the standard units used in the rest of the district's dams.[23]

The U.S. Army Corps of Engineers continues to develop and improve Tainter gate technology on the Upper Mississippi River. The Corps recently completed Lock and Dam No. 26R (the Melvin Price Lock and Dam), which replaced the aging Lock and Dam No. 26. On the new dam, the Corps utilized state-of-the-art Tainter gate technology. Each of the 9 non-submersible gates of Dam No. 26R measures 110 feet across and 42 feet high. As such, the new gates are nearly 3 times the length of the gates of the original Dam No. 26, and nearly 40 percent larger than the 80-foot gates erected at Dam No. 24. However, the principal difference between the modern gates of Dam No. 26R and those constructed in the 1930s is their enormous size. The Corps built and operates Dam No. 26R in essentially the same fashion as the earlier 9-foot channel complexes.[24]

The abandonment of the roller gate dam system on the Upper Mississippi was a logical progression in river hydrotechnology. The Corps replaced the Mississippi River's roller gates with Tainter gates in the same way that it replaced the Ohio River's wicket gates with roller gates. Thus, many of the dams on the Upper Mississippi River have a particular significance because they represent a technology that is no longer designed or constructed, due to advances reflected in the system's own unique evolutionary designs.



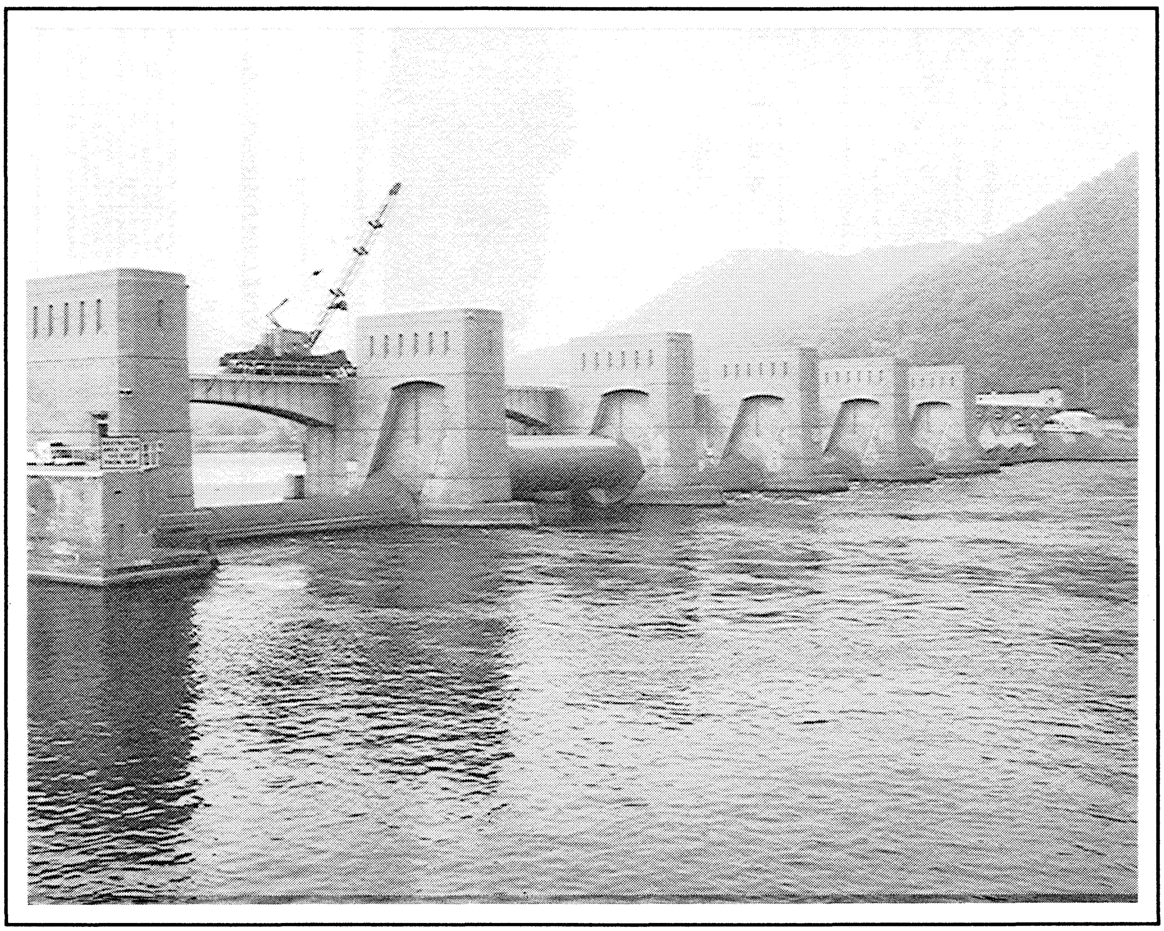
The pre-1936 roller gate piers have buttress detailing, large industrial sash windows, rubbed concrete wall finishes, and hipped roofs. Dam No. 6. (Clayton B. Fraser, Fraserdesign)

Architecture of the 9-Foot Channel Project

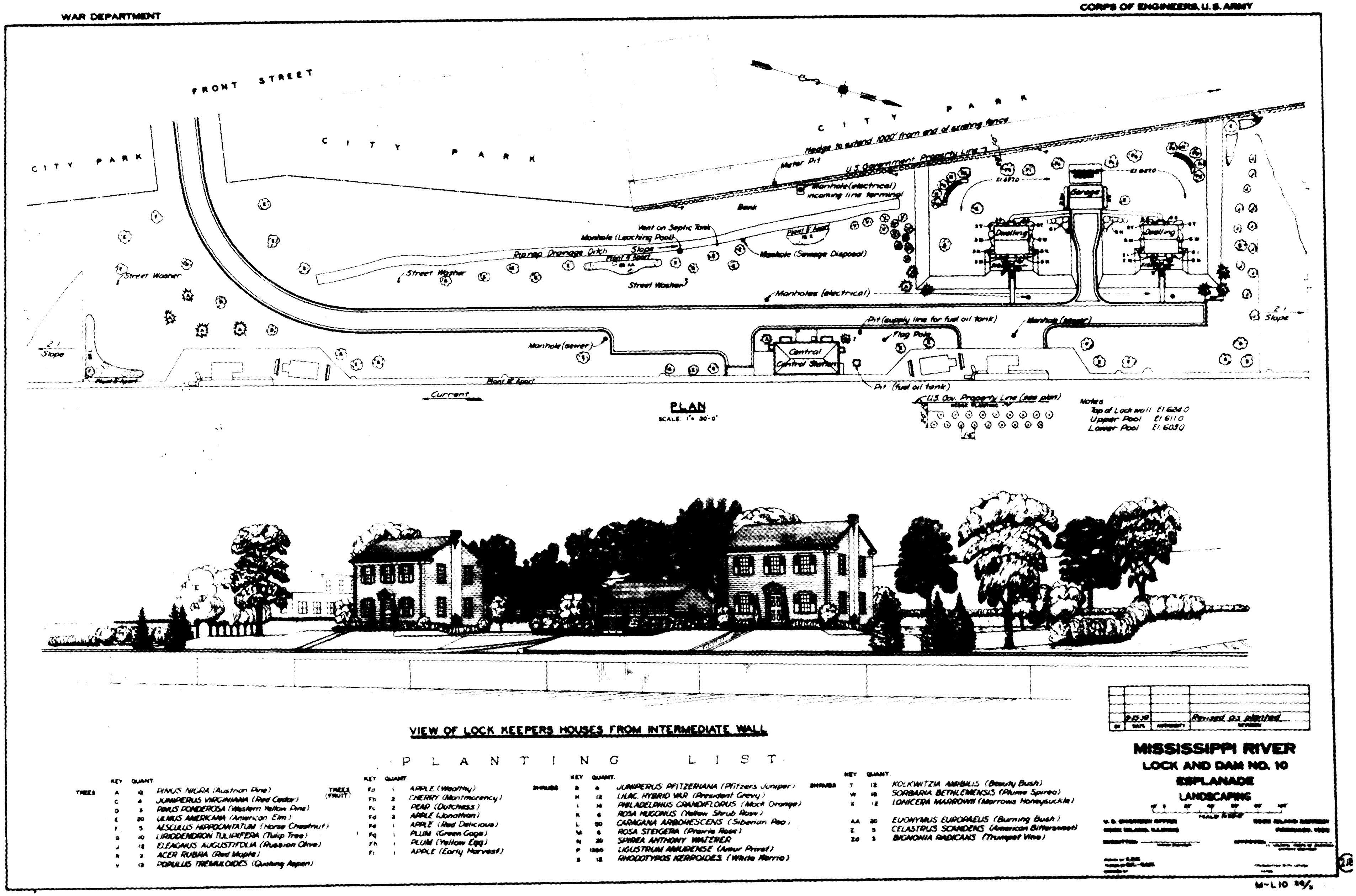
As in the case of engineering, the architectural designs of the Upper Mississippi River 9-Foot Channel Project also evolved over the 10-year construction period. The Corps of Engineers employed two distinct architectural styles in the navigation structures of the 9-foot channel, which can generally be identified by their date of construction. Dams built before 1936 are relatively ungainly and utilitarian in design. By contrast, post-1936 structures reflect sophisticated, streamlined, Art Moderne styling.[25]

The Corps of Engineers constructed the 9-Foot Channel Project during the Depression of the 1930s, and the changes in architectural design owe much of their evolution to the same era. The 1933 Century of Progress Exposition held in Chicago focused on national and international advances in technology and engineering, including the work of German designers. It is very likely that these currents affected the 9-Foot Channel Project, especially when viewed in light of the comparisons that were already being made between German roller gate designs on the Rhine and the Corps' work on the Upper Mississippi River.

Passages from the Century of Progress Exposition's guidebook reflect the post-1936, dam pier design of the 9-Foot Channel Project: "Consider the architecture of the buildings. Wonder, perhaps, that in most of them there are no windows. Note curiously that these structures are for the most part unbroken planes and surfaces of asbestos and gypsum board . . ." Architecture and planning were seen as elements of a "huge experimental laboratory" designed to further modern concepts in both fields. As the Corps of Engineers was completing the Upper Mississippi 9-Foot Channel Project, the 1939 World's Fair in New York again focused on technology, but this time without German participation. Nevertheless, the Depression-era "message of the modern" had not been lost on America's engineers. The Corps of Engineers had manifested that message into the concrete and steel structures of the 9-Foot Channel Project.[26]



The pier houses of the Moderne, post-1936 structures are incorporated into the overall pier design of the dam structure. The roofs are flat, and the buildings have slit, three-pane windows. Dam No. 5A. (Clayton B. Fraser, Fraserdesign)

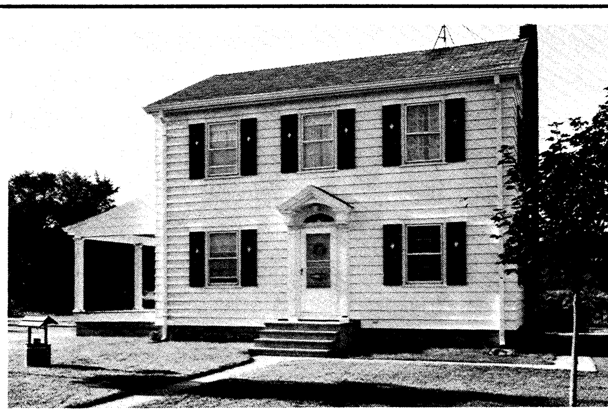


Lock and Dam No. 10, Esplanade and Landscaping Drawing, February 1938. (U.S. Army Corps of Engineers, St. Paul District)

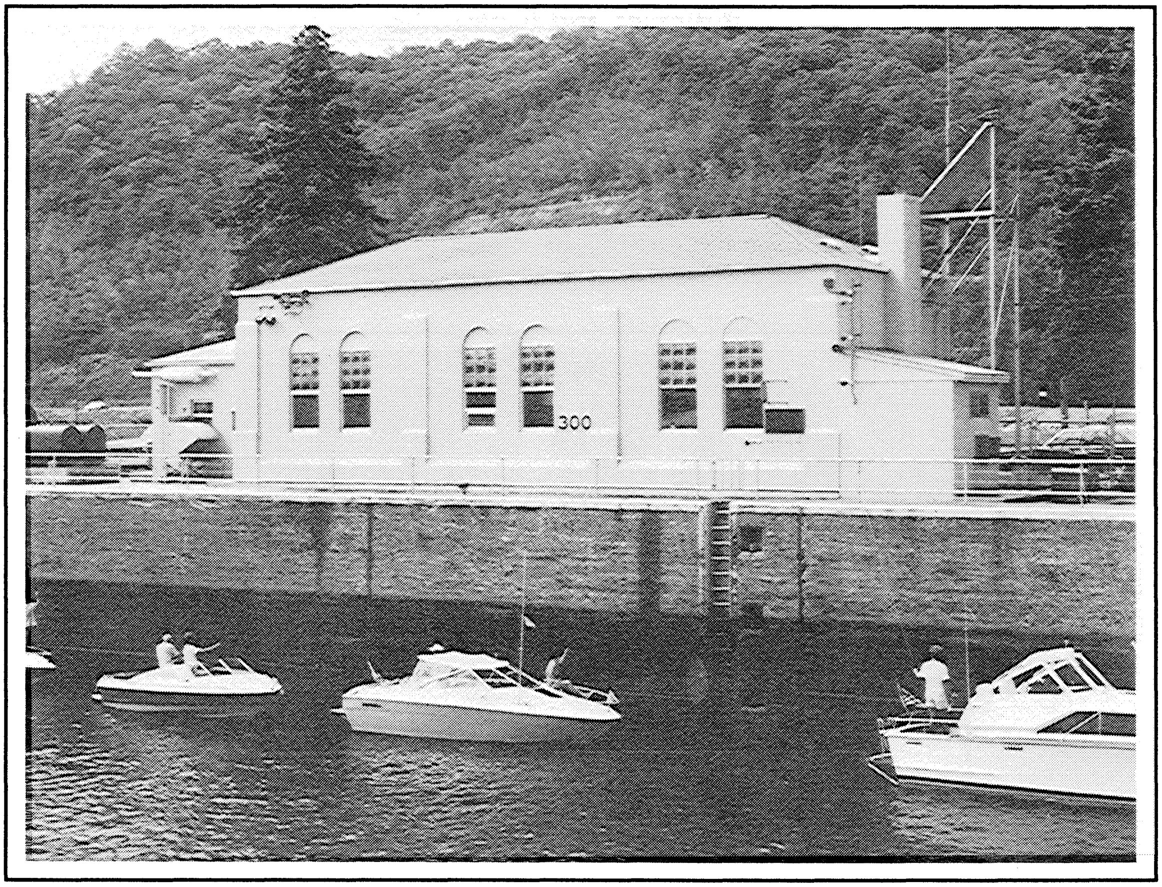
Buildings and Esplanades

The Corps of Engineers also designed the lockmasters' and assistant lockmasters' residences, control stations, and other ancillary buildings at each 9-foot channel site. Like the navigation structures, these buildings are simple and utilitarian. In these cases, however, the Corps borrowed from Colonial and Georgian models, rather than modern.

Living Room of Lockmaster's House, Lock and Dam No. 10, February 1938. (U.S. Army Corps of Engineers, Rock Island District)



Lockmaster's House, Lock and Dam No. 8. (Clayton B. Fraser, Fraserdesign)



Corps architects designed the 9-Foot Channel Project control stations with neoclassical arched windows and simple detailing. In all cases, simplicity was the hallmark of design. Central Control Station, Lock and Dam No. 7. (Clayton B. Fraser, Fraserdesign)

Locks

The Corps of Engineers modeled the general lock design for the Upper Mississippi River after the Ohio River canalization. As on the Ohio River, the standard Upper Mississippi River lock measures 110 by 600 feet, and is equipped with miter gates. The Corps of Engineers had originally used roller-type gates on the Ohio River locks, but malfunctions caused by ice and sediment encouraged the development of a new gate system. By 1913, the Corps had perfected a miter gate design for the Ohio River locks, a mechanism consisting of two hinged panels that, when closed, forms a miter point or "V" configuration pointing upriver. Miter gates are located at both ends of a lock, opening and closing to allow river traffic to pass through the chamber.

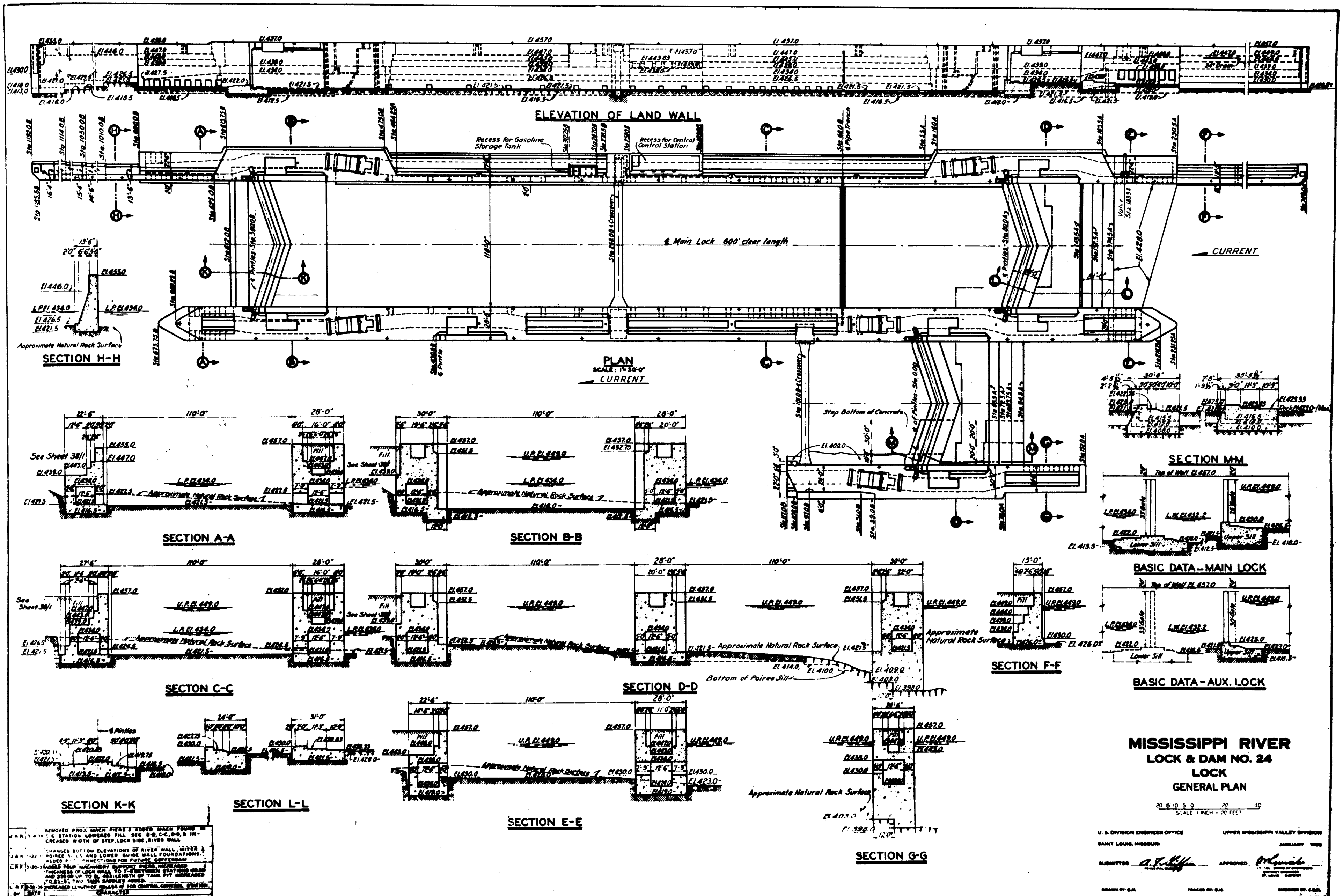
Although the Corps refined the design, miter gates were the most traditional type of lock gate and had been used for hundreds of years on canal locks prior to their use on the Ohio and Mississippi Rivers. There were few problems involved in designing miter gates when the locks they enclosed were 18 feet wide, an average mid-nineteenth century size. By the 1870s, miter gates reached widths of 80 feet, which were still workable. But when Corps engineers began designing 110-foot-wide miter gates for the Davis Island Lock on the Ohio River, they concluded that such large miter gates were not feasible with available materials. This ushered in a 30-year period in which the Corps either restricted miter gates to an obsolete 80-foot width, as in the case of the Rock Island District's Moline and Le Claire locks, or experimented with other types of lock gates.[27]

In 1913, the Corps' Louisville District engineering staff under William H. McAlpine, who later played such a significant role on the Upper Mississippi River 9-Foot Channel design team, finally solved the engineering problems inherent in developing a 110-foot-wide miter gate. The Louisville engineers combined an interior bracing frame, surrounded by steel-skin plates, with the traditional flat-leaf form of a miter gate. The resulting gate was strong enough to do its job well, yet light enough to be easily operated. This 1913 miter gate design was used on the Upper Mississippi River, with Corps engineers continuing to refine the design throughout the course of the 9-Foot Channel Project.[28]

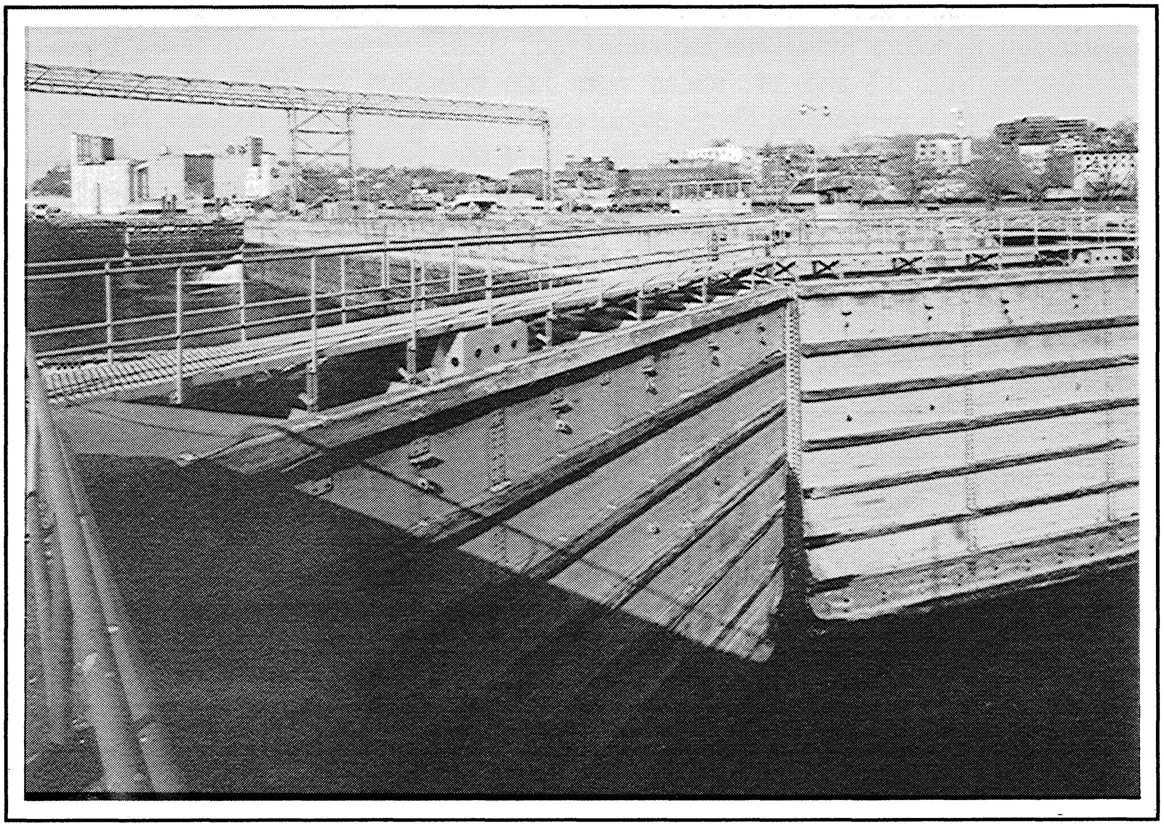
The most significant alteration to the Ohio River design involved the plan of the culverts and ports used to flood and empty the lock chambers. To fill and empty the chamber, the Ohio River locks utilized a series of small culverts passing directly through the lock's river wall above and below the dam. Each culvert was individually controlled by a valve. On the Upper Mississippi, Corps engineers replaced this complex arrangement with a system of large longitudinal culverts, controlled by four valves located in the base of the lock walls. This system provided greater dependability and required less maintenance. The Corps located the intake and discharge openings in the lock walls, respectively above the upper gates and below the lower gates. A series of small ports branched off the main culverts and flooded or emptied the lock chamber.[29]

The Upper Mississippi River engineers decided to use Tainter valves to control the flow of water into and out of the lock chamber. This design feature also represented a significant departure from the Ohio River project, where a roller valve design had been developed. The special Board of Engineers, in their final survey report of December 1930, had not dictated the design of the valves and operating machinery for the locks. However, the report noted that three types of valves were suitable: Stoney roller valves similar to those used in the Panama Canal locks; butterfly valves, such as those used at the Emsworth and Dashields Dams on the Ohio River; and Tainter gates, as used on the Welland Canal. The Tainter valves that were ultimately incorporated into the Upper Mississippi River locks function in the same way as the Tainter gates in dams. The Tainter valves are raised and lowered by electrically-driven cable hoists. In the lowered position, the seals on the sides and bottom of the valves close off the culverts, preventing water from either entering or leaving the lock chamber.[30]

Corps engineers perfected other aspects of lock design during the 9-Foot Channel Project. Rock Island engineers experimented with rubber gate seals rather than the conventional wood-on-concrete seals. The Corps also corrected problems in lock gate operating machinery. At Lock No. 20, the original specifications called for single-speed



Lock No. 24 Construction Drawing, January 1936. (U.S. Army Corps of Engineers, St. Louis District) motors that allowed 1 minute for opening and closing the gates. Before these machines were installed, however, the Corps' experience with 1-minute cycles at Lock No. 15 showed this speed to be too great for safe operation. As a result, engineers reworked the motors for the lock gates at No. 20 for a two-speed operation. The high speed winding developed 25 horsepower (hp.) at 1200 revolutions per minute (r.p.m.), resulting in a closing time of 1 minute. The low speed winding developed 5 hp. at 300 r.p.m. for a closing time of 4 minutes. These re-worked motors served the lock effectively for over 50 years.[31]



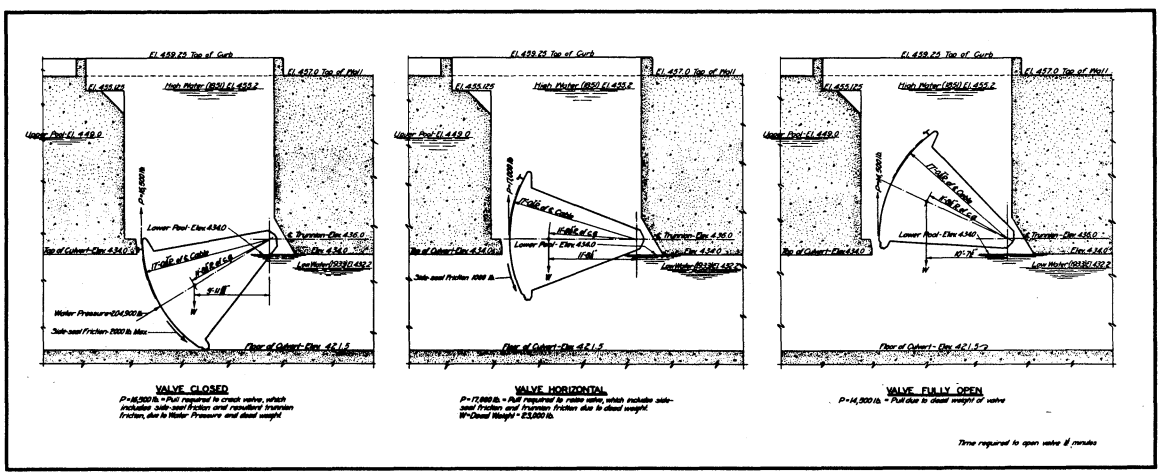
Miter gates are electrically operated. Motor assemblies housed in machine pits in the lock walls power the arms and gears which open and shut the gates. The lockmaster controls each pair of gates independently by switches located in weather-proof cabinets on the lock walls. Miter Gate on Auxiliary Lock No. 26. (John P. Herr, John Herr Photography)

The Corps also had to contend with outdrafts, or varying water currents, in the design of the locks. Upon completion of Lock No. 20 in 1935, the engineers discovered that strong outdrafts were making navigation in and out of the upstream end of the lock very difficult. In an effort to cut down on the outdraft, the Corps ordered the lockmaster's staff to keep the Tainter gate closest to the lock closed as much as possible.

The engineers also encouraged tow operators to hire an extra tow boat to help hold the head of their tow in place.

Locks Nos. 11, 16, and 18, completed in 1937, had equally severe outdrafts. Locks Nos. 21 and 22, completed in 1938, also had outdraft problems. Rock Island engineers now realized that they had made inadequate engineering assessments. As a result, the district staff began experimenting with designs that could retrofit all six locks. The engineers developed a 500-foot, concrete, cell foundation extension to the upstream end of the riverward wall of the auxiliary lock. The foundation cells extended almost to the surface of the upper pool. Only a small portion of the wall was underwater, offering virtually no obstruction to the flow of water. By May 1940, the Rock Island District had adapted this structure for all the individual lock sites.[32]

Locks Nos. 13 and 14, which went into operation in 1939, also had strong outdrafts. Here, however, the Corps engineered different solutions. At Lock No. 14, the Corps adapted the riverwall extension directly to the riverward wall of the main lock. At Lock No. 13, Corps engineers added a simple 1,064-foot-long mooring levee extension to the upstream guidewall. With the upstream guidewall extended, boats could be physically held against the guidewall. The Corps added a similar mooring levee extension to the upstream guidewall at Lock and Dam No. 15.[33]



Tainter valves, which control the flow of water in and out of the lock chamber, work on the same principle as the Tainter gates in the dams. Construction Drawing for Valve Operating Machinery for Lock No. 24, October 1935. (U.S. Army Corps of Engineers, St. Louis District)

The extensions of the upstream guidewalls at Locks Nos. 13 and 15 proved such a success that the district installed similar, but smaller, additions to Locks Nos. 11, 21, and 22. District engineers added approach flow deflecting dikes at Locks Nos. 11 and

22, where the outdrafts were more severe. They also added extensions to the upstream landwalls at Nos. 11 and 22, and a transitional section of approach dike and a mooring cell to No. 13. However, engineers still had to deal with outdrafts at the other nine complexes in the district.[34]

The Corps of Engineers designed all of the 9-foot channel installations with main and auxiliary locks but, at most of the complexes, the auxiliary locks were never completed. The Corps constructed auxiliary lock foundations, and equipped the incomplete locks with emergency gates. These gates open when the pool is drawn, allowing river traffic to pass. At some sites--Nos. 1, 15, 19, 26, 26R, and 27--the Corps completed the auxiliary locks because the dams are so high that there is no other way to provide for passing navigation except through the locks. The additional lock can also be used in case of accident or repair to the main lock, or as an auxiliary should increased river traffic require it.[35]

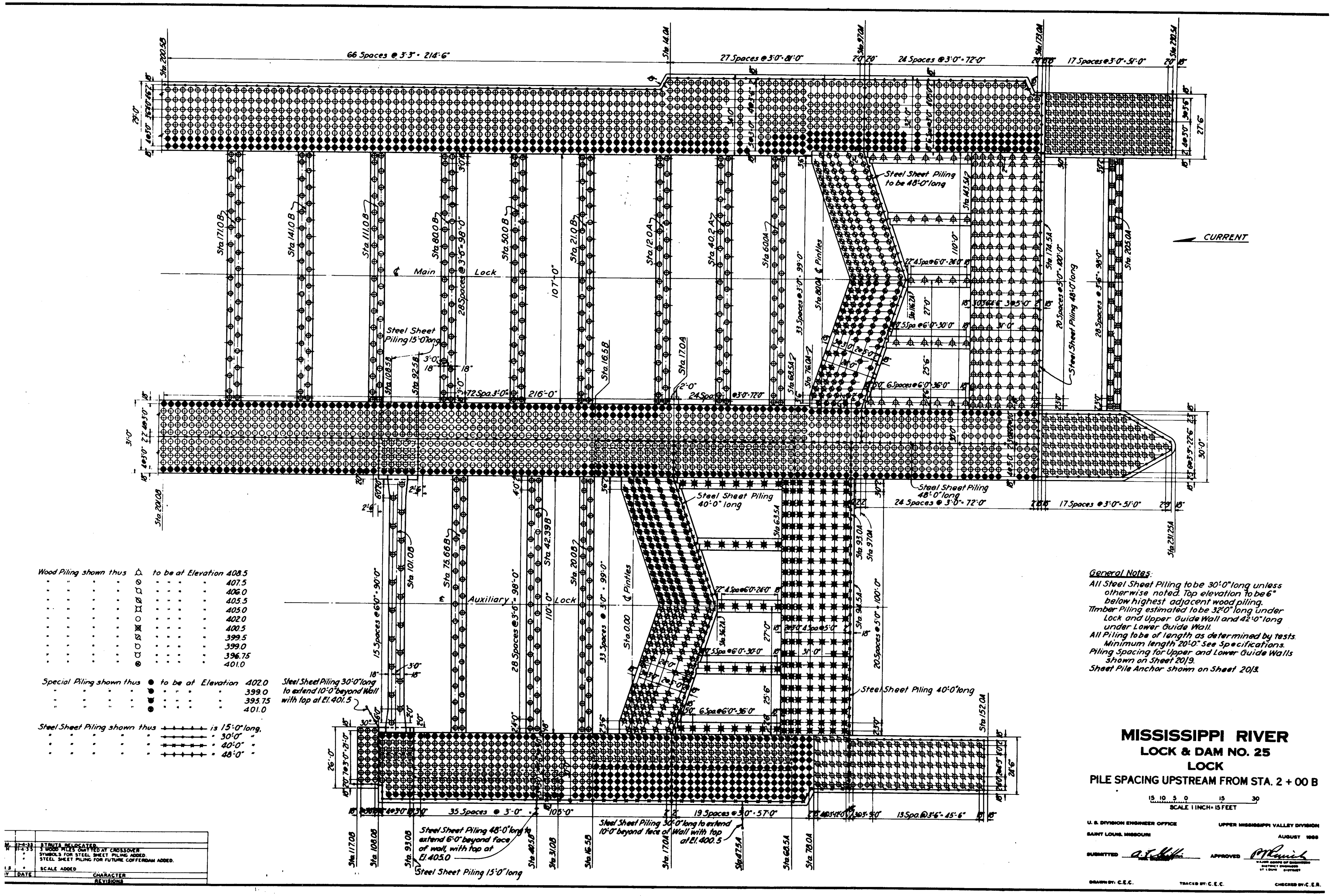
Foundations

In some river locations, Corps engineers situated the 9-foot channel locks and dams on bedrock, which provided a firm foundation. At others sites, however, the Corps located the locks and dams on silty, sandy riverbed. Here, the Corps had to support the concrete foundations of the locks and dams on a multitude of pilings driven into deep layers of riverbed sand--challenging conditions that called for specific engineering solutions.

The disparate foundation conditions that confronted the Corps can be seen within the Rock Island District. Foundation construction was not a particular problem for the four Rock Island District lock and dam systems sitting on bedrock: Nos. 14, 15, 20, and 22. But seven other complexes had to be built on sand: Nos. 11, 12, 13, 16, 17, 18, and 21. At these locations, the district built the structures upon concrete foundations set on sealed timber pile configurations.

By 1934, however, Corps engineers had learned that the land walls of the locks resting on the timber pilings did not have adequate stability. The lock land walls were incapable of resisting the horizontal thrust imposed by the back filling necessary to create the lock esplanades. To remedy this situation, the engineers added a series of reinforced concrete struts to the foundations of the lock chambers. The top of these struts were level with the lock floor. Thus, a portion of the horizontal thrust imposed on the landwall by the esplanade fill carried to the riverward wall of the lock. The engineers also required struts between the land walls and the riverward wall of the lock upstream from the upper miter sill and downstream from the lower miter sill.[36]

Similarly, Rock Island engineers redesigned the foundations of the guidewalls at several locks. The UMVD had departed radically from standard practice in designing the guidewall foundations. Traditionally, guidewalls were located on rock foundations, where such foundations existed. During the 9-Foot Channel Project, however, the Corps constructed guidewalls on timber cribbing partially filled with rip-rap. Concrete was



The placement of the foundation pilings delineated the final shape of the lock and dam structures. Pile Spacing Plan for Lock No. 25, August 1935. (U.S. Army Corps of Engineers, St. Louis District) supported on timber stub pilings either placed directly on rock or driven to refusal. The substitution eliminated the necessity of expensive cofferdams for this portion of the work.

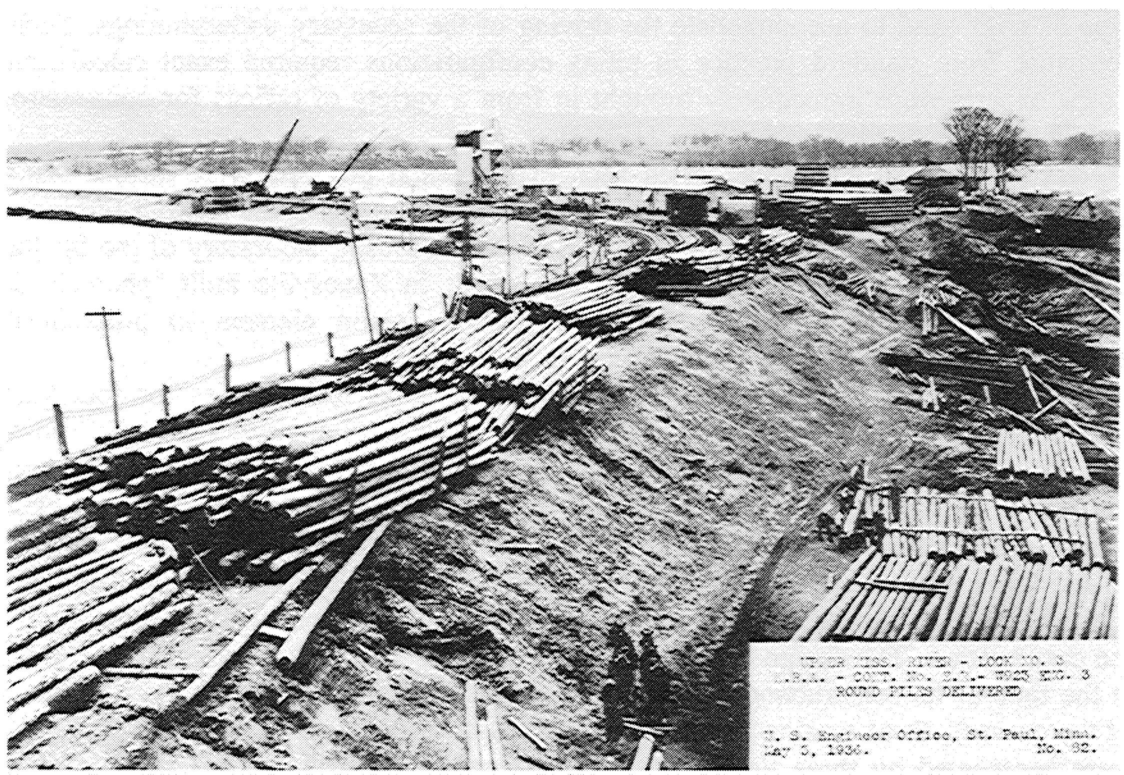
But Corps engineers discovered that the guidewalls at several of the locks resting on pilings had the same weakness to back fill as the land walls. To solve this problem, the Corps held an inter-district conference. Struts could not be used, since no riverwalls existed to absorb horizontal stress. Therefore, the conferees decided that battered piles with a wider crib and some additional vertical piles would give the necessary support.[37]

The St. Paul District also arrived at unprecedented solutions for some of its lock and dam foundations. Unlike the sites at St. Anthony Falls, Minnesota, where the substrata of sandstone and limestone enabled unshored methods of construction, Locks and Dams Nos. 3-10 required concrete foundations set on pilings. At Lock and Dam No. 3, district engineers decided to entirely replace the dam substrata with a more stable type of river sand to accommodate the driving of the necessary underpinnings. Such a departure from standard practice in piling configurations required exact calculations. Corps experts were immediately brought in from a variety of offices for consultation, including William McAlpine of the UMVD.

The Corps of Engineers tested such experimental procedures at various testing centers, including the University of Iowa, the Soils Laboratory at the District Engineer's office at Zanesville, Ohio, and the Fountain City, Wisconsin, laboratory of the St. Paul District. The staff of the District Engineer's office in Zanesville built "photoelastic" models that simulated the unstable strata with a gelatin element to pinpoint the difficulties related to stable foundation design.[38]

The St. Paul District implemented other innovative technologies for foundation construction. For some 9-foot channel foundations, St. Paul engineers used "Z" piling, a type of steel piling first rolled only 2 years before the beginning of the 9-Foot Channel Project. "Z" piling was useful in situations calling for maximum resistance to buckling or bending. The name "Z" comes from the shape of the piling; when one pile interlocks with another or a group of such materials, the result places the maximum amount of metal away from the neutral axis. The "Z" piling configuration gives great strength to the construction. The design of the curved portion of the abutment was felt to be unique at the time of its construction. In order to prevent "bulging" (radial pressure at the fill of the curves), three tension bands were used at varying elevations. These heavy plates were augmented by three lighter plates to ensure additional strength. One end of the outer plate was anchored in concrete. The plate then followed around the exterior of the abutment. Connection to the other end of the plate was followed along the straight section of the abutment and welded to the "Z" piles. The tendency for outward movement at the corner was deflected by the "wrapping action" (circumferential tension) in the steel plating. This method of engineering and construction was an unusual application of "Z" piling and was observed with great interest by contemporary engineers.[39]

As in the case of the St. Paul District, the Corps of Engineers made specialized testing a critical component of the 9-Foot Channel Project. Corps engineers tested the project's technology on a daily basis, with every conceivable element of the project receiving expert scrutiny. Such tests provided valuable research that formed the basis for future improvements. When tests of critical importance were not available in contemporary literature, Corps personnel developed their own. In some cases, as in the testing of substrata stability for the Lock and Dam No. 3 foundations, the ultimate decision to remove the unstable silt layer corrected the problem and rendered the testing results moot. Other experiments failed entirely, as in the design of an auger with specially designed flaps for the retrieval of soil samples from beneath the riverbed. Nevertheless, the Corps of Engineers' research contributions to the body of engineering knowledge remained important.



With conditions ranging from bedrock to sand, the Upper Mississippi riverbed provided a challenge for the U.S. Army Corps of Engineers. At Lock and Dam No. 3, the Corps entirely replaced the original substrata with a more stable type of river sand, which provided better support for the pilings. Timber piles being delivered to the Lock No. 3 work site, May 1936. (U.S. Army Corps of Engineers, St. Paul District)

Positive results quickly evolved from the research and testing process. For example, experimentation in cofferdam design in relation to seepage at Dam No. 6 enabled Corps engineers to improve cell design and configuration, as well as pumping methodologies. Because of its special substrata conditions, Lock and Dam No. 3 provided the impetus for testing everything from trial concrete mixes to probe resistance and soil density. Corps engineers also conducted load, pile, and paint tests, as well as tests for concrete temperature. The 9-Foot Channel Project engineers also drew upon earlier Corps projects for information. Corps engineers at the Huntington District's London Lock and Dam on the Kanawha River in West Virginia had done concrete testing that helped the Upper Mississippi River engineers in their pursuit of elusive data and computation of probable effects of construction.[40]

Contractors also entered the testing realm. The New York firm of Spencer, White & Prentis, the general contractor for Lock and Dam No. 6, developed a new type of skid pile driver that was built on the job site. Vulcan Number One steam hammers equipped the pile drivers; steam power was provided by the Chicago, Burlington and Quincy Railroad. The contractors also developed a new method of keeping pile hammers level, based on a circular steel slot bolted and welded to the hammer's side. The improved pile hammers drove the piles and sheets plumb, eliminating the need for guide lines.

In order to determine pumping needs, Lazarus White, president of Spencer, White & Prentis, also constructed a model of the Lock No. 6 cofferdam at a scale of 1:24. According to the project report, "The effect of berm and ditches and the relation between depths of sump and elevation of water were clearly demonstrated by the model and the results and information obtained many times justified its cost."[41]

The St. Louis District also made major advances in the analysis of the load bearing capacity of pile-founded structures. In St. Louis, Principal Engineer Lawrence B. Feagin recognized that little field data existed for determining the resistance of piles subject to lateral loads, such as those resulting from backfill against the locks land walls, or water pressure behind lock walls and dams. Lock No. 26 was designed to be founded upon 14,200 timber piles, including 5,000 concrete piles placed in those areas that supported the greatest loads. Feagin resolved to determine the degree of safety afforded by this type of construction for Lock and Dam No. 26 and future projects within the district.

Feagin conducted a series of tests upon groups of vertical piles subjected to static and cyclical loadings. These tests provided information on the behavior of the foundation piles under constant and changing loads, and led to a modification of the original lock design that introduced a series of pile-founded concrete struts extending, at floor level, between the land wall and the intermediate wall, and between the intermediate wall and the river wall. These struts distributed the horizontal loads among the three locks walls, reducing the load on any single wall. Feagin conducted similar load tests upon groups of batter piles at Lock and Dam No. 25, and incorporated batter piles, as well as lock wall struts, into the design of this structure. Lock No. 24, which rested upon a bedrock foundation, did not require the extra structural support afforded by the struts.[42]

At Lock and Dam No. 26, the movement experienced by both structures greatly exceeded the limits projected by Feagin's testing program, indicating that the pile foundations were "grossly underdesigned." Nevertheless, Feagin's pile load tests represented a pioneering effort in the scientific analysis of pile-founded structures. Prior to Feagin's efforts, engineers had little field data regarding the way large pile-founded structures behaved under loads. Feagin's testing program, though inadequate by modern standards, provided a wealth of information on this vital subject.[43]

The Corps conducted numerous tests to determine the load-bearing capacity of pile-founded structures. The results of those tests often resulted in the redesign of the lock and dam structures, as was the case at Lock and Dam No. 25. Driven Pilings at Dam No. 25, May 1938. (U.S. Army Corps of Engineers, St. Louis District)

During the 9-Foot Channel Project, the U.S. Army Corps of Engineers also devoted a great deal of time to the design of the dam sill and apron to assure that water passing over the spillway did not carry off foundation sands. In timber-driven foundation pilings, the structure gains significant structural stability from the sands that surround the pilings. Loss of sand through erosion, frequently the result of scour, can significantly reduce the structure's stability.

In the 9-Foot Channel Project, Corps engineers designed the movable gates on each dam to include an elaborate stilling basin. These stilling basins served to control the water's hydraulic jump and dissipate its energy so that it flowed placidly downstream. The first element of the stilling basin consisted of a reinforced concrete apron located directly below the dam sills and extending 36 to 52 feet downstream. Corps engineers varied the length of the apron according to gate type and hydrological conditions. A series of concrete baffles, positioned at the upstream edge and midpoint of the apron, dissipated the energy of the water passing over the spillway. Engineers placed timber mattresses laden with derrick stone against the edge of the apron, as well as an additional 48 feet downstream, to protect the pile foundations from scour. Timber and stone mattresses protected the upstream face of the dam. The Corps also drove steel sheet pile cutoff walls above and below the dam to prevent the passage of water directly beneath the structure.[44]

CHAPTER SEVEN NOTES

1.Tweet, Transportation on the Mississippi and Illinois Rivers, 82; Old Man River 4, No. 1 (January 1937): 15-20; 4, No. 9 (September 1937): 12-15; 2, No. 5 (December 1935): 8-13; 3, No. 8 (October 1936): 19-22; 4, No. 5, (May 1937): 16-21; 5, No. 3 (March 1938): 12-18; 5, No. 2 (February 1938): 2-21, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB; "Project Information: Upper Mississippi 9-Foot Channel Project prepared by U.S. Corps of Engineers Office, Corps of Engineers, St. Paul District, St. Paul, Minnesota" (n.d., n.p.) (photographs); Leonard H. Dicke, "The Upper Mississippi River Waterway," 1-5, RG77, subgroup: St. Paul District, General Records 1934-1943, 9-Foot Channel Project, Box 39, Entry 1629, File 4013.1/66 to 4013.1/86, NAKCB; Gjerde, "St. Paul Locks and Dams," 128-161 (site map and section elevation reproductions); "The Upper Mississippi River Canalization Improvement" (U.S. Army Corps of Engineers, U.S. Division Engineer, UMVD, St. Louis, Missouri, February 1938, revised May 1939, revised May 1940) 1-17; and Elliot, "Movable Gates," passim.

2."Roller-Gate Dam Erection," 410.

3.In 1902, a Krupp roller dam was built on the Main River near Schweinfurt, Germany. Soon roller gates predominated on both the Main and the Neckar Rivers. The roller dam at Kibling, Germany, which was built before 1915, involved a particularly remarkable use of the technology. This dam had one 28-foot high roller providing a 46-foot clear span. Another interesting pre-1915 example is a dam near Stuttgart, Germany, which had two spans, 92-foot by 12-foot. McAlpine, "Roller Gates in Navigation Dams," 420; Roberts, "Kanawha River," 338; "Building the Rolling-Crest Dam Across Grand River," Engineering News 76, No. 2 (July 13, 1916): 60; Johnson, Davis Island Lock and Dam, 162; and F. Teichman, "Large Roller-Crest Dam, Grand Valley Project, Colorado," Engineering News 76, No. 1 (July 6, 1916): 4. Although individual roller gates had been built in Europe that were both larger and longer, Dam No. 15 was the first to incorporate so many gates of such an aggregate length.

4.P.S. Reinecke, "The Rhine and the Upper Mississippi," The Military Engineer 30 (May-June, 1938): 167-171.

5.McAlpine, "Roller Gates in Navigation Dams," 420-421; and Roberts, "Kanawha River," 338, 340-342.

6."U.S. Engineer Office, Improvement of Mississippi River, Development Near Rock Island, Illinois, Hearing on December 22, 1930," 67; Leland R. Johnson, Men, Mountains and Rivers: An Illustrated History of the Huntington District, U.S. Army Corps of Engineers (Huntington: U.S. Army Engineer District, 1977), 137-138; and Johnson, Davis Island Lock and Dam, 162.

7.Teichman, "Large Roller-Crest Dam," 4.

8.Ibid., 2-4; and "Building Rolling-Crest Dam Grand River," 60-61.

9.Roberts, "Kanawha River," 339. Vertical lift gates' name explains their technology well. The rectangular sliding gates at Dam No. 19 on the Upper Mississippi are a form of vertical lift gate. Sector gates are roller gates in which the roller is a sector of a circle instead of a cylinder. John S. Scott, A Dictionary of Civil Engineering, 2nd ed., (Baltimore: Penguin Books, 1965), 270.

10.Roberts, "Kanawha River," 340; and H. Doc 137.

11.The original German-designed gates that the Corps started with at Rock Island were those covered by the MAN Company patent as fabricated by the S. Morgan Smith Company. They were almost identical to those used at the New England Power Association's Bellows Falls Dam. H. Doc 137, 97. Discussions relevant to reasons for the modifications in these original designs are in Gross and McCormick, "Upper Mississippi River Project," 315-316; and Roberts, "Kanawha River," 340. Standard roller gate construction is covered in "Building Roller-Crest Dam Grand River," 61-63. Construction dates on Dam No. 15 are covered in Final Report Lock and Dam 15, 60. Completed on March 31, 1934, the dam was halfway done in 1933.

12.Roberts, "Kanawha River," 340-341.

13.Gross and McCormick, "Upper Mississippi River Project," 316; E.E. Gesler to Div., October 9, 1937, and E.E. Gesler to Chief, November 12, 1937, and May 28, 1938, RG77, Entry 111, Box 998, File 3524-Part 2; and RG77, Entry 111, Box 197, Envelope 7425.

14.L. Ylvisaker to Dravo Contracting Company, November 16, 1932, 1, RG77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry 1626a, File 413b.3/05, NACB; Contracting Engineer, M.H. Treadwell Company to United Construction Company, January 12, 1934, 1-3, March 3, 1934, 1-4; United Construction Company to District Engineer, St. Paul, Minnesota, February 26, 1934, 1-2; RG77, subgroup: St. Paul District, Box 395861, File 413b.3, NACB; Old Man River 2, No. 5 (December 1935): 25-28, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB; Lieutenant Colonel E.L. Daley to District Engineer, U.S. Engineer Office, St. Paul, Minnesota, February 20, 1934; Major Dwight Johns to United Construction Company, February 20, 1934; Lieutenant Colonel E.L. Daley to M.H. Treadwell Company, Inc., February 17, 1934; United Construction Company, Winona, Minnesota, to District Engineer Office, St. Paul, Minnesota, February 17, 1934; M.H. Treadwell Company, New York, to United Construction Company, February 15, 1934; Captain Homer Pettit to United Construction Company, February 6, 1934; Lieutenant Colonel E.L. Daley to M.H. Treadwell Company, January 31, 1934; Major Dwight F. Johns to United Construction Company, February 13, 1934; Lieutenant E.L. Daley to M.H. Treadwell Company, January 24, 1934; M.H. Treadwell Company to United Construction Company, January 23, 1934; and United Construction Company to District Engineer, St. Paul, Minnesota, RG77, subgroup: St. Paul District, Box 395861, File 413.b3, NACB.

15.Elliot, "Movable Gates," 3.

16.Ibid., 8; William P. Creager, Joel D. Justin, and Julian Hinds, Engineering for Dams, 3 vols., (New York: John Wiley & Sons Inc., 1945), 3: 893; and Armin Schoklitsch, Hydraulic Structures: A Text and Handbook (New York: American Society of Mechanical Engineers, 1937), 648-657.

17."Patent Lock Gate," The Farmer's Journal, Welland Canal Intelligence 39 (October 17, 1827); Deposition of William A. Gooding, October 19, 1850, in George Heath v. George W. Hildreth, Civil Action a-1363, Fifth Judicial District of the Supreme Court of the State of New York, Herkimer, NY; G.W. Hildreth, Canal-Lock Gate, Patent No. 1517, Patented March 19, 1840; G. Heath, Hydraulic Canal Gate, Patent No. 2393, Patented December 14, 1841; Heath v. Hildreth, Case No. 6,309, October 15, 1841, Circuit Court, District of Columbia; New York State Assembly Doc. No. 201, April 21, 1846; New York State Assembly Doc. No. 18, January 15, 1844, New York State Assembly Doc. No. 91, February 22, 1944; New York State Assembly Doc. No. 216, May 5, 1846; Johnson, Davis Island Lock and Dam, 135, 162; Mary Yeater, "Hennepin Canal Historic District," National Register of Historic Places Inventory-Nomination Form, Section 7: 2-3; and Gjerde, "St. Paul Locks and Dams," 125-128.

18.Daley, "Canalization of Upper Mississippi," 106; and Elliot, "Movable Gates," 9.

19.Schoklitsch, Hydraulic Structures, 638-656, 679-681; Old Man River 2, No. 5 (December 1935): 27; and Creager, et al, Engineering for Dams, 1: 43.

20.R.A. Wheeler to Div. Engineer, August 16, 1935, RG77, Entry 111, Box 990, File 3524-part 2, WNRC; Drawings, No. M-L 18 10/39A; Annual Report 1940, 1160; Annual Report 1942, 1028; and Annual Report 1951, 1237.

21.Mississippi River Lock & Dam No. 24, Dam--General Arrangement--Tainter Gate, Drawing No. M-L 24 40/2 (December 1937); Elliot, "Movable Gates," 14; and Gross and McCormick, "Upper Mississippi River Project," 314.

22."Final Report Laboratory Tests on Hydraulic Model of Lock and Dam No. 22, Mississippi River, Hannibal, Mo.," RG77, Entry 111, Box 179, Envelope 7245, WNRC; R.A. Wheeler to Chief of Engineers, October 13, 1934, RG77, Entry 111, Box 993, File 3524-part 2, WNRC; "Mississippi River Lock and Dam No. 11, Final Report--Construction" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, 1938), (hereafter referred to as "Final Report, Dam 11") 10, 53, RG77, NACB; E.E. Gesler to Chief of Engineers, January 13, 1937, E.E. Gesler to R.W. Kaltenbach Corp., April 16, 1937, and E.E. Gesler to Div. Engineer, June 26, 1937, RG77, Entry 111, Box 975, File 3524, WNRC.

23."Final Report, Dam 11," 51, 56; and Drawings, Nos. M-L 11 58/1, 58/1A, 58/1A.1, and 58/1A.2, and M-L 18 58/2A.

24.Thorwald R. Peterson, "Replacement for Locks and Dam No. 26," The Military Engineer, 66 (1974): 287.

25.The architectural designs can also be differentiated by those structures for which the designs were completed between July 1931 and June 1934, and those completed between August 1934 and September 1936. William McAlpine and Lenvik Ylvisaker designed the first group; Edwin Abbott designed the second. C.W. Short and R. Stanley-Brown, Public Buildings: A Survey of Architecture of Projects Constructed by Federal and Other Governmental Bodies Between the Years 1933 and 1939 with the Assistance of the Public Works Administration (Washington D.C.: Government Printing Office, 1939), 509; U.S. Army Corps of Engineers, Drawings: River and Harbor Project--Mississippi River--Missouri River to Minneapolis Locks and Dams 3 through 10 (in two sheets for each complex) September 30, 1978; Jon Gjerde, HABS/HAER Inventory Cards--Locks and Dams 3 through 10, February 26, 1983; U.S. Army Corps of Engineers, "History of Construction--Dam No. 3, Red Wing, Minnesota," (n.d.); "Dam No. 4, Alma, Wisconsin," (E.J. Christenson, ed., n.d.); "History of the Construction of Dam No. 5, Mississippi River 4.8 Miles Downstream from Minneiska, Minnesota," (submitted by V.C. Funk, January 31, 1936), 77; "History of the Construction of Dam No. 8 Mississippi River--Genoa, Wisconsin--September 14, 1935--April 30, 1937," (submitted by Frank E. Rutt, Jr. Engineer, Acting Resident

Engineer, n.d.), passim, St. Paul District Office Records; Wood, "A Nine Foot Depth in the St. Paul District," 6; Old Man River, January 1938, 14-16, RG77, subgroup: St. Paul District, Box 2, Entry 1626, NAKCB; and William Patrick O'Brien, National Park Service, Rocky Mountain Regional Office, field inspection, May 7-12, 1987.

26.U.S. Army Corps of Engineers, Drawing: "Mississippi River Lock and Dam Number 10--Esplanade Landscaping, February 1938, Rock Island District", No. ML10-38/3, St. Paul District Office Records, Map Division, St. Paul; O'Brien, National Park Service Field Inspection, May 7-12, 1987; Calvin D. Linton, ed., The Bicentennial Almanac: 200 Years of America (New York: Thomas Nelson, Inc., 1975), 332, 347; Henry B. Ward, ed., "The American Association for the Advancement of Science: Preliminary Announcement of the Summer Meeting To Be Held in Chicago From June 19 to 30, In Connection With The Century of Progress Exposition," Science 77, No. 2003 (May 19, 1933): 463, 474; Reinecke, "The Rhine and the Upper Mississippi," 161-171; The Symbol of Arcturus, official guidebook of the Century of Progress International Exposition (Chicago: A Century of Progress, Inc., 1933), passim; and Lois Craig, et al., 398-399.

27.The Illinois and Michigan Canal, completed in 1848, was a typical mid-nineteenth century canal; its locks were 18 feet wide. Mary Yeater Rathbun, The Illinois and Michigan Canal (Springfield, Ill.: Illinois Department of Conservation, 1980), 23; Ben Hur Wilson, "The Des Moines Rapids Canal," Palimpsest, April 1924, 120-130; Tweet, Rock Island District, 93-103; and Johnson, Davis Island Lock and Dam, 53-54.

28.Johnson, Louisville District, 176.

29.H. Doc. 137, 98.

30.Ibid.

31."Mississippi Lock and Dam 20; Final Report Construction," Vol. I: "Introduction and Lock" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, March 1935) (hereafter referred to as "Final Report Lock 20"), 24, 48; "Final Cost Report Dam 20 Mississippi River" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, June 1936) (hereafter referred to as "Final Cost Dam 20"), 1-2, RG77, Entry 81, Box 666, NACB; R.A. Wheeler to Chief of Engineers, November 16, 1933, and July 23, 1934, RG77, Entry 111, Box 993, File 3524-Part I, WNRC; and Drawings, Nos. M-L 20 20/1 and 40/1.

32.Mary Rathbun interview with G. Ron Clark and James Wright, U.S. Army Corps of Engineers, Lockmaster and Former Lockmaster (respectively) of Lock and Dam 20, Canton, Missouri, July 16, 1984 (hereafter referred to as Clark-Wright Interview); Inter-office Memo, May 21, 1940, RG77, Entry 111, Box 795, File 3524, WNRC; Annual Report 1940, 1160; Annual Report 1942, 1025, 1028; and Annual Report 1943, 943.

33.Annual Report 1942, 1028; and Annual Report 1951, 1237.

34.By 1951, engineers had developed a uniform remodeling program to handle the outdraft problems at all the lock systems in the district. Inter-office Memo, April 27, 1942, RG77, Entry 111, Box 975, File 3524, WNRC; Annual Report 1942, 1028; and Annual Report 1951, 1237.

35.H. Doc 137, 6, 21.

36.The final construction reports mention these being added at Locks 16, 18, 11, 21, 22, and 12--that is, all those in the district built on piles except Lock 17. It is not clear if the struts were not used at Lock 17 or were simply not added in. Lock 17 was the last lock constructed in the district. By then the struts may have been a standard feature drawn in at the initial design state and not meriting special mention. For a good description of the struts and their function see "Mississippi River Lock and Dam 21 Final Report-Construction," Vol. I:"Introduction and Lock" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, August 1939), (hereafter referred to as "Final Report Lock 21"), 8-9, RG77, NACB.

37.R.A. Wheeler to Chief of Engineers, May 3, 1934, RG77, Entry 111, Box 997, File 3424, WNRC.

38.L.E. Wood, "Historical Sketch: Construction of L/D No. 3," Old Man River 5, No. 3 (March 1938): 12-18; and Old Man River 2, No. 5 (December 1935): 27, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

39.William Z. Lidicker, "Mississippi River: Lock and Dam No. 3," Old Man River 4, No. 9 (September 1937): 12-15, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB; and Lidicker, "Unusual Timber and Steel Bearing Pile Load Tests at Mississippi River Dam No. 3" (July 26, 1939), 1-13, RG77, subgroup: St. Paul District, General Records 1934-1943, Documents and Publications: Authorities for Publications of Articles, Box 22, Entry 1629, File 54.7, NAKCB.

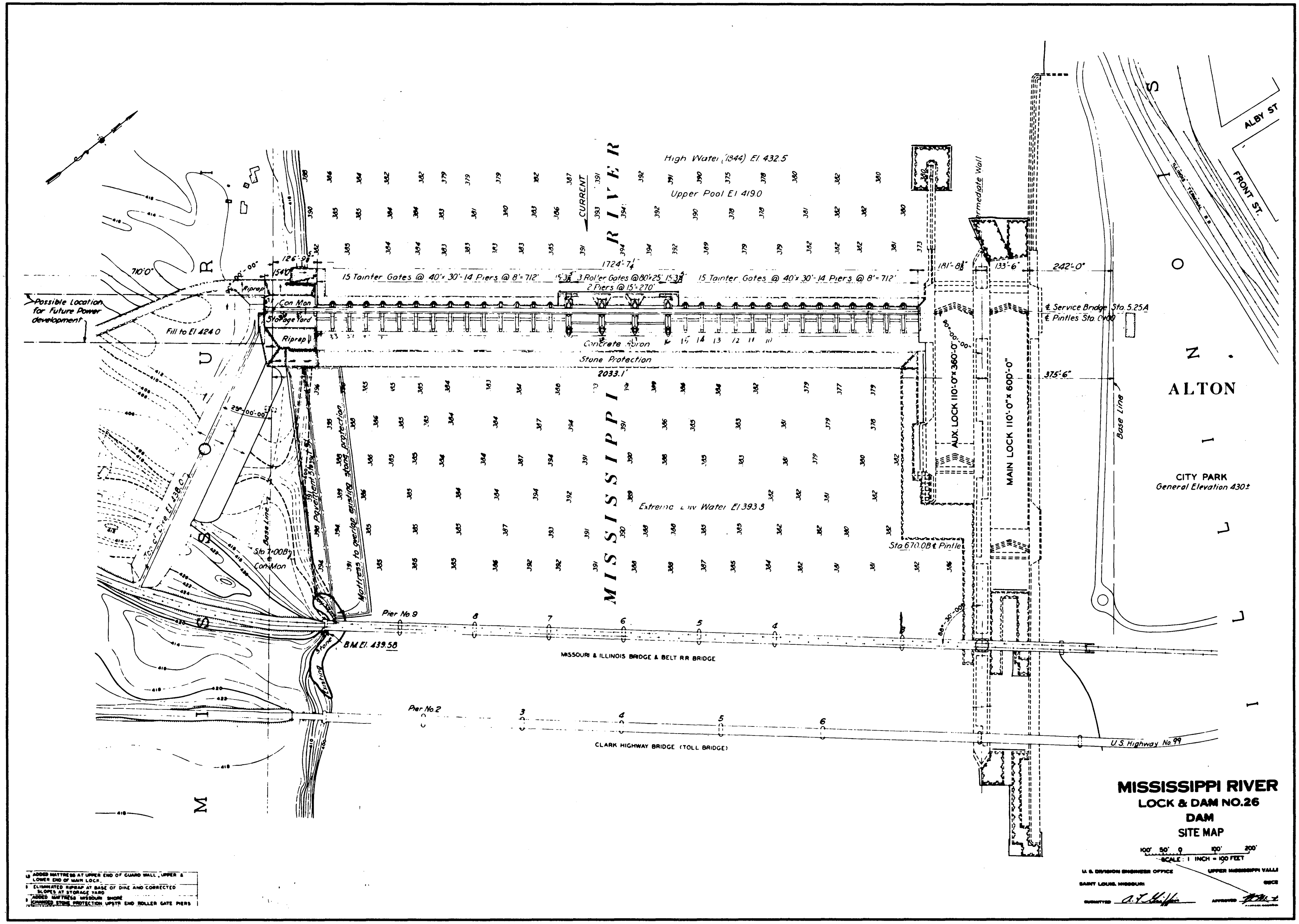
40.Herbert G. McCormick and John W. Dixon, "Mississippi River Cofferdams," The Military Engineer 28, No. 158 (March-April 1936), 105-08; Harry Carlson, "Report on Test of Relation Between Probe Resistance and Soil Density" (U.S. Army Corps of Engineers, St. Paul District, 1938), 1-5; Carlson, "Report on Trial Mixes for Dam Number 3" (U.S. Engineering Laboratory, Fountain City, Wisconsin, n.d.) 1-6, "Report on Investigations of Foundation Soil Densities at Dam No. 3" (U.S. Army Corps of Engineers, St. Paul District, 1937), 1-6, and E.J. Christenson, three memoranda: "Preliminary Report(s) on Load Test Nos. 3, 4, 5, Dam No. 3," June 23, 1937, 1-2, 1-2, 1-3, RG77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395851, Entry 1626a, File 313b.3, NACB; R.R. Philippe, memo: "Foundation-Lock No. 3," June 12, 1936, 1-6, RG77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395848, Entry 1626a, File 313a.3, NACB; "Discussion of Trial Mixes," (typewritten, n.d.), 1-42, RG77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395871, Entry 1626a, File 505.1, NACB; and Major Dwight F. Johns to District Engineer, Huntington, West Virginia, June 27, 1934, Lieutenant C.T. Hunt to District Engineer, St. Paul, Minnesota, June 14, 1934, and "Report on Tests on Temperature Rise In Concrete Conducted At London Lock and Dam, Kanawha River, Huntington District," (n.d., typewritten) 1-9, RG77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395857, Entry 1626a, File 405.1/11-4, 4/1, NACB.

41.Francis A. Landrieu, Ralph D. Salisbury, Mark Haima, George E. Oliver, and Lee H. Baron, "History of the Construction of Lock 6--Mississippi River--Trempealeau, Wisconsin--P.W.A. Project 11," (U.S. Army Corps of Engineers, April 1935, typewritten) 16-17, St. Paul District Office Records, Saint Paul, Minnesota.

42.Thomas J. Mudd, "Locks and Dam No. 26, Mississippi River--Alton, Illinois" (St. Louis: U.S. Army Corps of Engineers, St. Louis District, 1975), 3; and "History and Cost Report Lock 24, Mississippi River" (St. Louis: U.S. Army Corps of Engineers, St. Louis District, 1938), 1, typescript draft on file in St. Louis District Office.

43.Mudd, "Locks and Dam No. 26," 3-4; and "Final Report--Lock and Dam No. 26, Part I--Locks" (St. Louis: U.S. Army Corps of Engineers, St. Louis District Office) (hereafter referred to as "Final Report--Locks and Dam No. 26, Part I"), 16, 32, 34, typescript draft on file at St. Louis District Office.

44.Mississippi River Lock & Dam No. 26, Dam--General Plan, Drawing No. M-L 26 40/1 (December 1934); Mudd, "Locks and Dam No. 26," 3; Mississippi River Lock & Dam No. 25, Dam--General Plan, Drawing No. M-L 25 40/1 (January 1937); and Mississippi River Lock & Dam No. 24, Dam--General Plan, Drawing No. M-L 24 40/1 (December 1937).



Lock and Dam No. 26 was located immediately upstream from two railroad and highway bridges. As a result, Corps engineers incorporated the bridges' piers into the design of the lock walls. Lock and Dam No. 26 Site Map, December 1934. (U.S. Army Corps of Engineers, St. Louis District)

CHAPTER VIII

Case Study: The Construction of Lock and Dam No. 26

The U.S. Army Corps of Engineers built 29 lock and dam complexes on the Upper Mississippi River. The construction of those complexes, and the decisions related to that process, greatly influenced the pace of technological development of the Upper Mississippi River 9-Foot Channel Project. Poor or misguided construction decisions invited disaster. Well-planned and well-executed construction efforts generated technical innovations and improvements at later sites. On the following pages is a detailed description of the construction of Lock and Dam No. 26, located near Alton, Illinois.

Lock and Dam No. 26 is being highlighted for several reasons. Lock and Dam No. 26 provides an excellent opportunity to examine the decision-making and construction methods, both efficient and inefficient, involved in the building of the 9-foot channel. The complex was also a somewhat "typical" 9-foot channel installation. The Corps of Engineers constructed Lock and Dam No. 26 between 1934 and 1938, during the middle phase of the Upper Mississippi River 9-Foot Channel Project. Many of the technological breakthroughs associated with the 9-Foot Channel Project were standard practice by the time work began on Lock and Dam No. 26.

The Upper Mississippi Valley Division designed the twin locks at installation No. 26 prior to the assignment of design responsibilities to individual districts at the close of 1933. As such, the lock design reflects the level of technology immediately following the earliest phases of the project. The Corps designed Dam No. 26 in 1934 and constructed it between 1935 and 1938. Corps engineers equipped the dam with thirty 40-foot-long, submersible, Tainter gates. The rapid evolution of Tainter gate design is perhaps the most significant technological achievement of the 9-Foot Channel Project. As one chapter of a larger story, the building of Lock and Dam No. 26 sheds light on the methods used to construct the 9-foot channel, and the wide range of technical innovations and improvements realized throughout the course of the project.

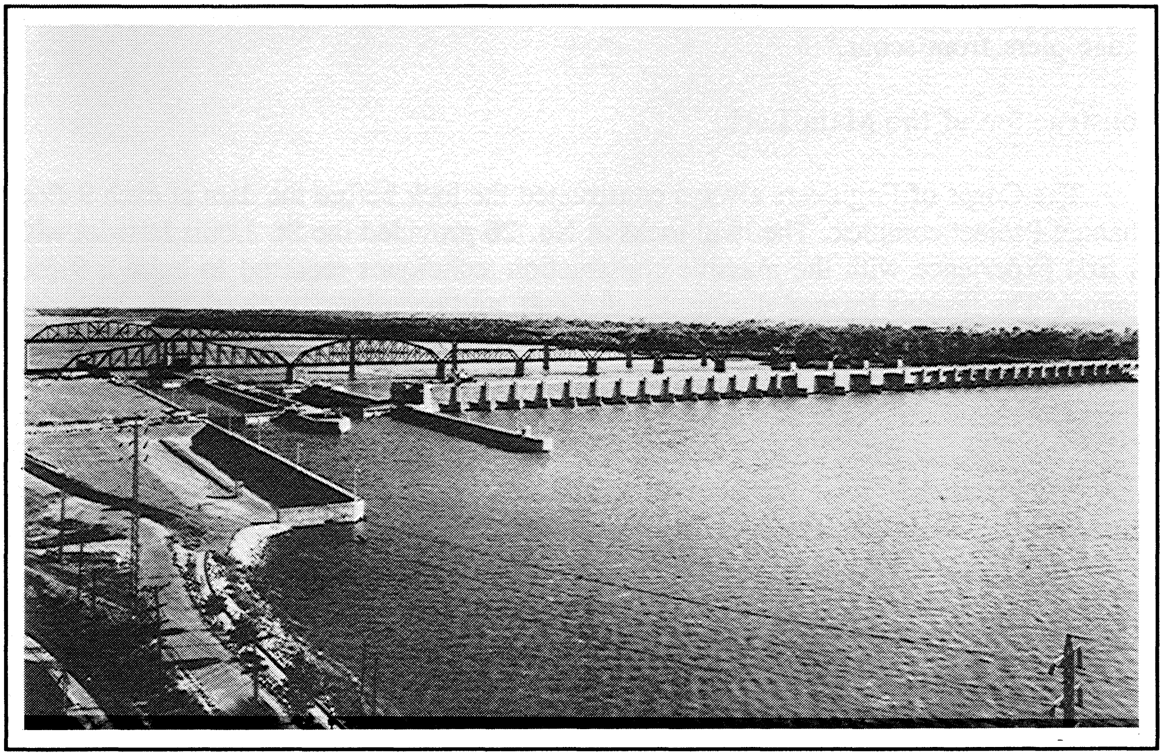
Lock and Dam No. 26 was also unique because it was the first Upper Mississippi River 9-Foot Channel Project complex replaced by a modern structure. The construction of the 9-foot channel on the Upper Mississippi had vastly increased the amount of barge traffic on the river. The tonnage passing through Lock and Dam No. 26, the southernmost lock and dam complex constructed during the 1930s, increased from 1.4 million tons per year in 1938, to 55 million tons in 1975. This enormous increase in traffic severely taxed the operational capacity of the installation and ultimately led, with a variety of other factors, to the construction of a new facility. The Corps of Engineers removed the original installation in 1990, and completed the construction of Lock and Dam No. 26R, also known as the Melvin Price Lock and Dam, in 1991. In Lock and Dam No. 26R, the Corps of Engineers incorporates the most modern design lessons and philosophies, representing the culmination, for the moment, of Mississippi River navigation improvement technology.[1]

Authorization and Site Selection

The U.S. Army Corps of Engineers located Lock and Dam No. 26 approximately 23 miles above St. Louis, placing it under the jurisdiction of the St. Louis District office. Because the authors of House Document 137 realized that the 1930 authorizing act had not appropriated enough money to complete the 9-Foot Channel Project, they developed a plan for progressively building the channel as funds became available. Under the plan, Corps officials placed each lock and dam complex in one of four groups: A, B, C, or D. Because they were necessary for existing commerce, Group A structures were slated for immediate construction. Group B structures, which were located in areas that did not have a dependable 6-foot channel, were the next priority. Although ultimately needed to secure a 9-foot channel, Group C and D structures were the lowest priority. All of the 9-foot channel installations in the St. Louis District, including No. 26, were "Group D" structures because dredging alone could maintain a 9-foot channel in this stretch of the Upper Mississippi River. Of these, Lock and Dam No. 26 was the first to be built.[2]

The Corps' special Board of Engineers originally recommended that Lock and Dam No. 26 be located just below Grafton, Illinois, approximately 1 mile below the mouth of the Illinois River. By September 1933, however, Corps officials relocated the site to Alton, Illinois, approximately 20 miles below the point where the Illinois River joins with the Upper Mississippi. Corps engineers determined that the navigation pool formed by Dam No. 26 would create backwater 80 miles up the Illinois River. As a result, Lock and Dam No. 26 would facilitate barge traffic on both the Mississippi and the Illinois Rivers, making it a key element within a complex inland navigation system that ultimately extended from New Orleans to Pittsburgh, Chicago, Kansas City, and Omaha. Corps engineers often relocated lock and dam sites throughout the 9-Foot Channel Project. The recommendations of the special Board of Engineers' survey report were frequently discarded upon closer investigation of the lock and dam sites.[3]

In the case of Lock and Dam No. 26, the relocation appears to have been for more than just engineering reasons. Forty years after the fact, Tom Butler, the mayor of Alton, claimed the Corps moved the installation to Alton because Grafton did not have enough open space for an adequate storage and staging yard. According to Butler, Corps officials proposed to relocate the lock and dam installation to Alton, where the recently constructed Riverside Park offered an excellent site for a construction yard, if Alton would allow the Government to use the park site free of charge for the duration of the project. Faced with large-scale unemployment, the city quickly agreed to this proposition.



Lock and Dam No. 26, October 1938. (U.S. Army Corps of Engineers, St. Louis District)

Alton city boosters were also quick to realize the recreational benefits of the 9-Foot Channel Project. Some local residents saw the potential of utilizing the navigation pool for recreational purposes. Although the Corps of Engineers was allotted money to build public access roads to the navigation pool, Alton civic leaders successfully lobbied the Public Works Administration (PWA) for money to construct a scenic drive along the Upper Mississippi River from Alton to Grafton. The project, which received $900,000 in funding, also called for the employment of 1,800 federal relief workers.[4]

Although the relocation helped Alton's economy, it made little sense from an engineering standpoint. The Alton site was located immediately upstream from the bridges of the Missouri & Illinois Bridge & Belt Railway and the Clark Highway. As a result, the Corps was forced to position the locks in an awkward location. Corps engineers incorporated two of the existing bridge piers into the lock walls, creating a difficult approach into the lock chambers. The site also held the potential for creating scour problems at the railroad and highway bridges.[5]

William H. McAlpine, UMVD head engineer, signed the construction drawings for the twin locks at installation No. 26 in October 1933, shortly after the Corps secured the Alton site. Between 1933 and 1936, the Corps conducted model tests on the structure at the University of Iowa's Hydraulic Laboratory. As a result of these tests, Corps engineers designed the locks to have extensive stone and timber mattresses to protect the bridge piers from scour.[6]

Construction of the Main Lock

The Corps of Engineers always constructed the lock before the dam at each 9-Foot Channel Project complex. The twin locks at No. 26 provided the St. Louis District with its first experience with the massive construction techniques required to build a 9-foot channel. The lessons learned during this difficult, and occasionally disastrous, endeavor provided the Corps with valuable, albeit hard-earned, experience.[7]

In November 1933, the Corps of Engineers put twin locks No. 26 out for bid. When Corps officials opened the bids on December 19, 1933, they discovered that the bid of the John Griffiths & Son Company of Chicago was the lowest. The Griffiths & Son Company bid $3.2 million--$200,000 less than the next lowest bid, and approximately $350,000 less than the Federal Government estimate for the job. Griffiths & Son had an established reputation as large-scale contractors. They constructed both the massive Merchandise Mart and the main United States Post Office in Chicago. However, the firm had virtually no experience in the highly specialized field of river construction. Despite this lack of experience, Griffiths & Son received notice to proceed on the construction of the twin locks in January 1934.[8]

As discussed earlier, the 9-foot canalization had originated as a navigational improvement project but was reshaped into a massive public employment program during the New Deal administration of President Franklin D. Roosevelt. At twin locks No. 26, as at many other 9-foot channel sites, the public works aspects of the job became immediately apparent. Soon after the project's official announcement, Missouri and Illinois politicians began bitterly debating the composition of its work force. Missouri's Senator Clark demanded the labor force be split equally between residents of Missouri and Illinois. But Alton's mayor, Tom Butler, filed a protest with the Labor Department and Missouri's U.S. Senators, arguing that during the negotiations with the Corps for the use of Riverside Park he had been led to believe that the ratio of Illinois to Missouri workers would be three to one. Butler also argued that Madison County, Illinois, had a population six times that of largely rural and agricultural St. Charles County, Missouri, and six times the number of unemployed. Ultimately, Butler's arguments carried the day.[9]

Griffiths & Son relied almost entirely upon local laborers, importing only 15 to 20 key personnel from Chicago. The company hired workers at prevailing rates for the St. Louis metropolitan area, with common laborers earning 60 cents an hour. Unions, however, argued that these predetermined wages were below their regular rates and refused to furnish workmen. In May 1934, the Wage Predetermination Board of the Department of Labor ruled in favor of the unions and held that common laborers should be paid at least 67.5 cents per hour. Griffiths & Son estimated that this rate increase would raise the cost more than $40,300, which the Corps of Engineers agreed to cover.[10]

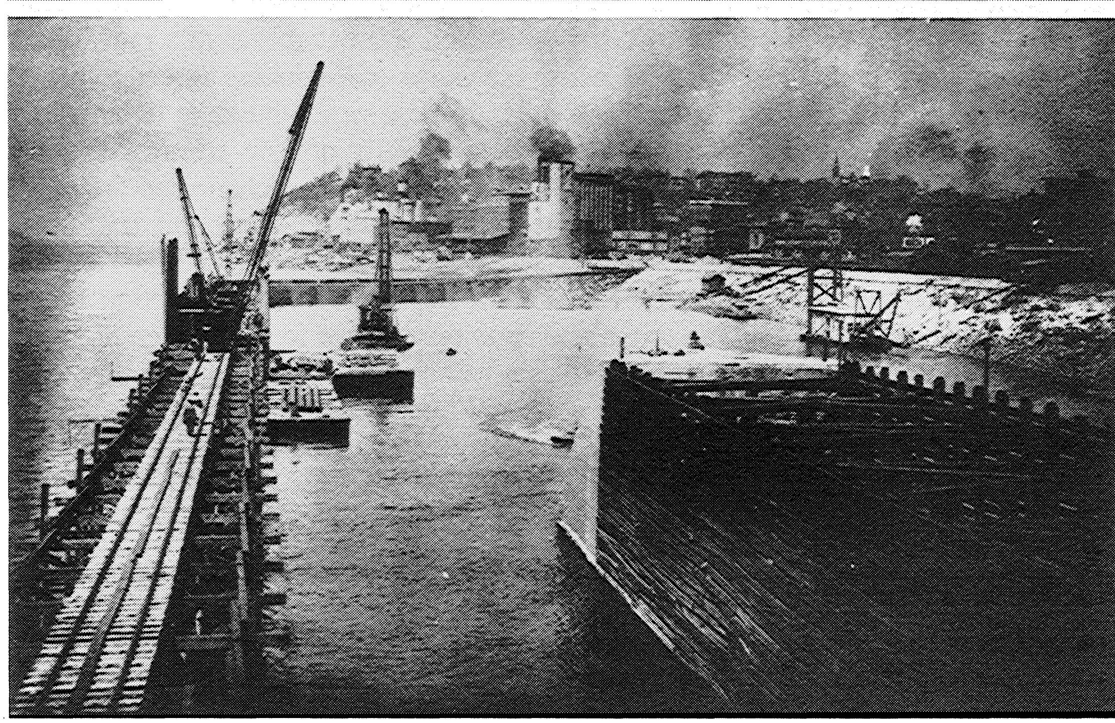
As at all the other 9-foot channel lock sites, the first step in building the main lock was the construction of a cofferdam. A cofferdam walls off the construction area, enabling the lock to be built "in the dry," while river traffic is rechanneled around the cofferdam. When the lock is completed, the cofferdam is removed and traffic goes through the open lock chamber while work progresses on the dam.

Cofferdams were one of the most important and expensive construction features of the 9-Foot Channel Project. Each contractor was responsible for the design of his own cofferdam. As a result, innovations in cofferdam technology originated with these firms rather than the Corps' design team. Failure of a cofferdam not only destroyed the work done during that contract, but also destroyed work completed by another contractor under a separate contract. Such failures became the subject of lengthy court battles over who had responsibility for the resulting damage. In some instances, these court cases went on for years, involving hundreds of thousands of dollars.[11]

Contractors on the Upper Mississippi 9-Foot Channel Project built two basic types of cofferdams: timber/crib configurations and steel sheet piling configurations. All the timber/crib cofferdams were Ohio River Box type, which had been used extensively since the 1870s. These cofferdams were typically comprised of wood sheathing inside a frame of horizontal walers and tie rods. The cofferdams at No. 26 were constructed of steel sheet piling.

The Corps of Engineers first used steel sheet piling cofferdams during its efforts to raise the Maine from Havana Harbor. Contractors working for the Corps of Engineers began using them on the Ohio River in 1917. However, William McAlpine, then supervisor of construction on the Lower Ohio and later head of the UMVD, discouraged their use. He believed the difficulty and expense of removing the pilings after the work was completed outweighed their advantages. McAlpine apparently continued in this belief at the beginning of the 9-foot channel on the Upper Mississippi, despite the reduced first cost of steel sheet piling and its high salvage value. As a result, contractors did not begin to use steel sheet piling cofferdams on the Upper Mississippi River until after McAlpine was transferred to the office of the Chief of Engineers, removing him from direct supervision of such project details. Thereafter, cofferdams made of steel sheet pilings were in very general use on the project.[12]

Corps officials approved Griffiths & Son's cofferdam design for Main Lock No. 26 in mid-January 1934. The company designed an exceptionally heavy and strong cofferdam for the site because of the existing swing span railroad bridge. The presence of the bridge required traffic to pass through the auxiliary lock area during construction of the main lock. This, in turn, dictated that the river arm of the main lock cofferdam be placed very near the intermediate lock wall, preventing construction of a suitable stabilizing berm on the inside of the cofferdam.[13]



A cofferdam walls off a portion of the river, providing a dry work site. Each contractor was responsible for the design of his own cofferdam. Griffiths & Son, the contractor for Main Lock No. 26, began by building a trestle along the center line of the cofferdam site. The trestle supported derricks and cranes that aided in construction and the delivery of materials. Cofferdam Construction for Main Lock No. 26, March 1934. (U.S. Army Corps of Engineers, St. Louis District)

Griffiths & Son began constructing the cofferdam on the first of February. The company enclosed approximately 13 acres of riverbed with the cofferdam, which consisted of a wall of semi-circular, steel sheet, pile cells. Work crews filled the cells with material dredged from the bottom of the river. Y-connection piles, connected to two structural frames, tied the individual cells together at the panel points. Outside wall piles measured 55 feet in length; inside wall piles were 40 feet long.

The riverbed at Alton consisted of a minimum of 80 feet of sand above bedrock, which forced construction of the cofferdam atop a pile foundation not driven to bedrock. The riverbed also proved particularly susceptible to scour at this location, which threatened to undermine the cofferdam. Griffiths & Son placed a pair of streamlined pile fins around the cofferdam to help smooth the flow of water and, presumably, reduce scour. Workers also placed ballasted brush and timber mattresses against the cofferdam to hold the foundation soil in place.

Griffiths & Son used construction methods for the cofferdam that were very similar to those used on dryland projects. First, the company constructed a wood pile-supported trestle along the center line of the cofferdam site. Railroad tracks atop the trestle supported a succession of derricks and cranes that aided in the construction of the sheet pile cells and the delivery of materials. The company constructed the trestle between early February and mid-April 1934. Workers began placing the steel sheet piling in early March and completed the job by the end of April.[14]

The contractor began draining the cofferdam in early May 1934. Serious seepage problems developed almost immediately. Griffiths & Son stopped the seepage by installing an extensive system of wellpoints that lowered the water surface 1 to 2 feet below grade. The wellpoint system represented an advance over previous methods that relied upon large surface pumps to discharge water from sumps. The new system, which appears to have been first used on the 9-Foot Channel Project in the Rock Island District in about 1933, cost more but afforded a drier work area. By mid-May, the cofferdam was dewatered to the point that Griffiths & Son's pile driver began placing foundation piles for an interceptor sewer designed to carry Alton's existing Piasa Street sewer below the locks.[15]

The 9-Foot Channel Project had generated little local opposition within the St. Louis District. However, Alton residents were concerned that the navigation pool created by the construction of Dam No. 26 would adversely affect the local sewage system. For the river towns along the Mississippi, sewage systems were often a significant source of local pride, serving as physical manifestations of the towns' participation in the urban improvement and reform movements that swept the United States during the decades following the 1893 Columbian Exposition. To alleviate concern that the increased river height would adversely affect sewers, the Corps designed and constructed interceptor sewers that carried the Piasa Street and State Street sewer outlets to a point below the locks.[16]

Workers began driving the first piles for the main lock's land wall in early June. In mid-June, they began working on the intermediate wall foundations. With the exception of the piling for some of the struts between the lock walls, all pile driving within the main lock cofferdam was completed by the end of October 1934. Griffiths & Son organized the pile driving operations into three 6-hour shifts, 5 days a week. Four pile drivers were in daily operation, with a fifth unit held in reserve. During a shift, each rig placed an average of 13 piles. The majority of the piles were 11-inch-diameter, 32-foot-long wood piles. Griffiths & Son's employees placed three rows of tapered, 32-foot, concrete piles on the river side of both the land and intermediate walls.

Workers also drove a single row of 40-foot, steel, sheet piling along the outside of the land wall, below the upper miter sill, and through the center of the intermediate wall. This piling acted as a cutoff, preventing the foundation sand from being carried away. Loss of this sand would have removed the lateral and vertical support from around the piles, creating stress and the possibility of a total structural collapse. Driving of the steel sheet cutoff walls began in late June 1934.[17]

The contractor began draining the cofferdam in May 1934; pile driving began the next month. By the end of October, all pile driving was completed. View upstream from cofferdam, October 1934. (U.S. Army Corps of Engineers, St. Louis District)

Unlike the remainder of the lock structure, the Corps located the upper end of the land wall on a rock-filled timber crib surrounding 56-foot wood piles. Griffiths & Son began constructing the cribbing in mid-September 1934. Below the reinforced concrete apron in front of the lower discharge ports, workers laid derrick stone directly atop the sand between the concrete struts to prevent scour. This protection, 4 feet deep and 30 feet wide, was largely placed from atop the intermediate wall.[18]

The lock's massive fixed sides were constructed of concrete masonry, the use of which had been pioneered by the U.S. Army Corps of Engineers. In 1891, Major William L. Marshall, the same officer who initiated the Corps' use of Tainter gates, had conducted the Corps' first "great experiment in river construction" when he used poured Portland cement, rather than cut stone, to construct lock walls on the Illinois and Mississippi (Hennepin) Canal.[19]

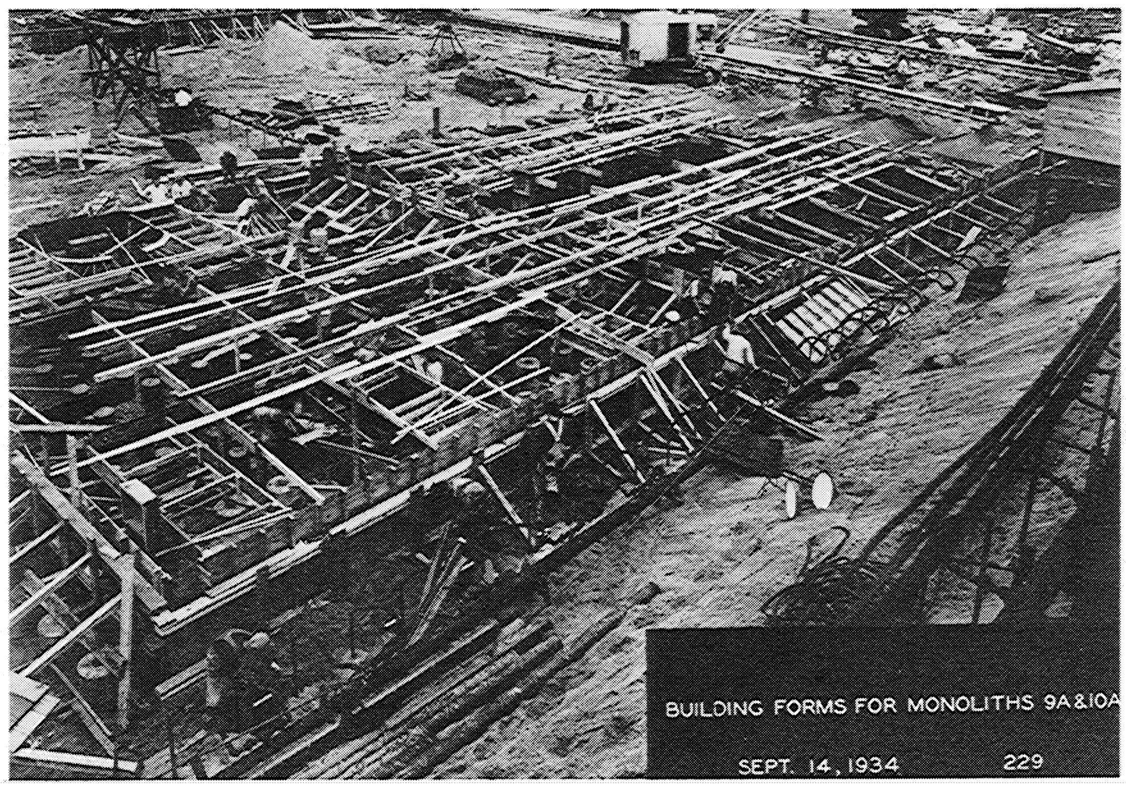
Concrete masonry walls were standard practice at the time of the 9-Foot Channel Project. However, the unorthodox construction techniques used by Griffiths & Son to build the concrete walls of Main Lock No. 26 were not. Griffiths & Son's choice of concrete placement would prove to be disastrous.

Griffiths & Son chose to place the concrete with belt conveyors, rather than the usual practice of using gantry cranes and concrete buckets. This decision was apparently made for practical and budgetary reasons; the company had a large number of belt conveyors stored in its Chicago material yard. But the decision had far-reaching effects. If Griffiths & Son had chosen to invest in gantry cranes, the company could have used large, heavy, concrete forms. By choosing to use equipment on hand, Griffiths & Son were forced to use small, easily handled, forms that could fit on belt conveyors.

The smaller forms that fit on the belt conveyors produced 5-foot-tall monoliths, which contained only 90 to 200 yards of concrete. These forms were so small that a standard day's production required the completion of five to eight monoliths, placing considerable strain upon the complex belt conveyor distribution system. The capacity of the concrete mixing plant, which was located on shore, exceeded that of the conveyors. When Griffiths & Son ran the mixing plant at capacity, concrete inundated the forms. This forced a delay of several minutes while the concrete was shoveled down and vibrated into place. Further complicating the process was the fact that workers needed to shift the belt conveyor distribution system each time they began working on a new monolith. The Corps of Engineers later estimated that the combination of light concrete forms and the belt conveyor distribution system added approximately $1.50 to the cost of each cubic yard of concrete above the cost of using gantry cranes and concrete buckets.

Griffiths & Son began placing concrete in mid-August 1934. The company had planned to construct the lock walls in a pyramidal fashion, broadening the base as the upper pours advanced. Throughout August, Griffiths & Son's workers placed concrete at the rate of one footing monolith per day. The small amount of yardage contained in the monoliths, and the large amount of carpentry work required to form each monolith, slowed production and prevented placement of more than 700 yards per day. The high form costs and disappointing progress led Griffiths & Son to increase the monolith heights to 10 and later 15 feet beginning in November 1934. Still, Griffiths & Son's workers were placing concrete well into 1935.

The delays in concrete placement caused a delay in steel erection. Steel workers could not begin until the top concrete lifts at the gate bays, which included the gate anchorages, were completed. Workers started erecting steel in mid-February 1935, beginning with the upper gate leaf for the intermediate wall. Griffiths & Son crews began riveting the upper gate leafs in early March, and the lower gate near the end of April. But Corps personnel at the site complained that Griffiths & Son's steel erection lacked organization and planning. Riveting gangs failed to follow closely upon the erection gang, despite repeated insistence on the part of Government engineers. The lack of gantry cranes also greatly delayed this phase of the construction. In March 1935, the Upper Mississippi River overtopped the cofferdam, further complicating the situation. The river deposited 4 to 12 inches of silt on the lock floor.



After the piles were driven, workers began building the monolith forms used for concrete placement of the lock walls. Construction of Main Lock No. 26, September 1934. (U.S. Army Corps of Engineers, St. Louis District)

Finally, Griffiths & Son completed the main lock in late September 1935, and began removing the cofferdam. However, the heavy construction of the cofferdam delayed its removal which, in turn, delayed the start of the auxiliary lock cofferdam. The company could not construct the auxiliary lock cofferdam, which would have blocked river traffic, until the completed main lock was open for navigation.[20]

Construction of the Auxiliary Lock

The U.S. Army Corps of Engineers incorporated provisions for auxiliary locks into the majority of the 9-foot channel sites. However, the Corps completed auxiliary locks at only two of the original 9-Foot Channel Project installations constructed between 1930 and 1940: Lock and Dam No. 15 and Lock and Dam No. 26. At the other locations, the Corps stubbed-in the foundations for auxiliary locks, but never built them. The Corps engineers equipped the auxiliary lock foundation with portions of the river wall, machinery recesses, and upper lock gates that could be opened for traffic during periods when the dam was fully raised and the pool drawn down.[21]

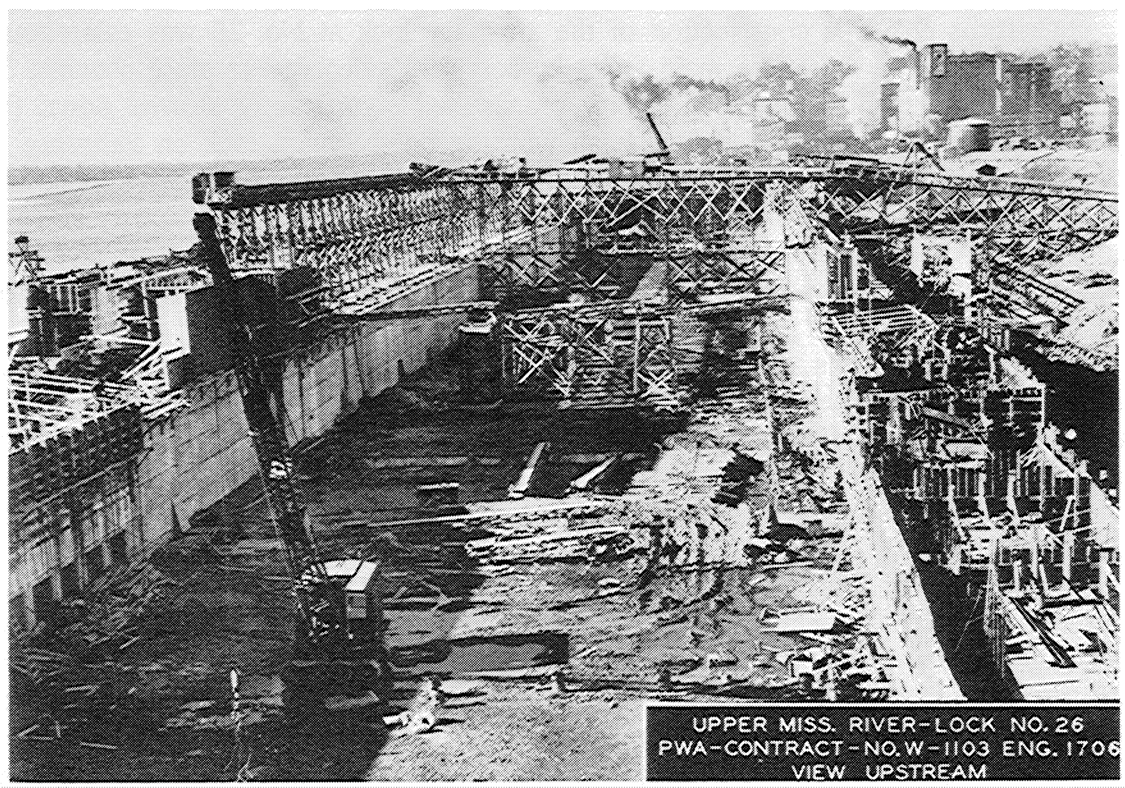
Griffiths & Son's construction of the auxiliary lock at No. 26 was calamitous. During the construction of the main lock, the company's decision to place concrete by using belt conveyors rather than gantry cranes had significantly slowed down the construction process. The company began working on the main lock on February 1, 1934, but did not complete the job until September 1935. By the time Griffiths & Son began constructing the auxiliary lock the following month, it was dangerously close to the onset of winter. While river ice conditions were less than ideal, they may have been manageable if they had not been combined with the contractor's unorthodox construction practices.

Griffiths & Son's crews began building the river arm of the auxiliary lock cofferdam in early October 1935. By mid-December, workers had completed both the river and lower arms of the structure. Then, despite the objections of the Corps' resident engineer, H.S. Pence, Griffiths & Son closed off the lower arm of the cofferdam in hopes that the river would deposit the 2 to 8 feet of fill required to bring the auxiliary lock site up to grade.

On December 19, 1935, the temperature fell sharply. On December 20, heavy ice started to run in the river. By December 26, the auxiliary cofferdam was filled with ice. In early January 1936, ice damaged a portion of the river fin, an extension of the cofferdam designed to streamline the flow of water around the structure. Repair efforts proved unsuccessful. As a stopgap measure, the Corps placed a barge loaded with derrick stone against the fin to protect it from the flowing ice. Griffiths & Son resumed cofferdam driving on January 15, and completed all but three cells in the upper arm of the cofferdam before cold and ice again halted the work on January 17.

Extremely low temperatures prevailed, and by the end of February the entire river was gorged with heavy ice. On the night of February 26, a large gorge of ice upstream from the lock broke up and caused considerable damage to the fin on the lock side of the cofferdam. On February 29, the river fin failed completely and the sheet pile cells of the cofferdam collapsed like dominoes. Almost the entire upper and river arms failed. In addition to the cofferdam, a crane, a steam hammer, and assorted other materials plunged into the river.

Following the collapse of the auxiliary lock cofferdam, Griffiths & Son began to disband their work force and remove their equipment from the job site. On March 18, 1936, in reply to a telegram from the District Engineer, Griffiths & Son stated that it was not obligated to assume the construction hazard associated with completion of the auxiliary lock, since the Corps had ordered the Engineering Construction Company, the contractors for the construction of Dam No. 26, to proceed with the second section of the dam cofferdam. The District Engineer notified Griffiths & Son of the Government's intention to terminate their contract on April 2, 1936. On April 7, Griffiths & Son informed the Corps that it had abandoned work and would proceed to remove its equipment and material.



By January 1935, the construction of Main Lock No. 26 was well underway. (U.S. Army Corps of Engineers, St. Louis District)

With the departure of Griffiths & Son, the Corps was left with the responsibility for removing the collapsed cofferdam, as well as preventing damage to the completed main lock. In late April 1936, the Corps placed 820 feet of timber mattress against the intermediate lock wall to prevent scour. Throughout May, Corps crews also removed the standing cells of the auxiliary lock cofferdam to prevent eddies and facilitate the passage of river traffic. In June, Corps workers began searching for the collapsed cofferdam. In order to remove the cofferdam, the Corps had to know the precise location and depth of the collapsed cells. The cofferdam also had to be removed quickly in order to avoid delaying the dam contractor, who was expected to complete work within his second cofferdam by late fall of 1936. Divers successfully located the cells, which they found laying nearly horizontal beneath 8 to 18 feet of sand.

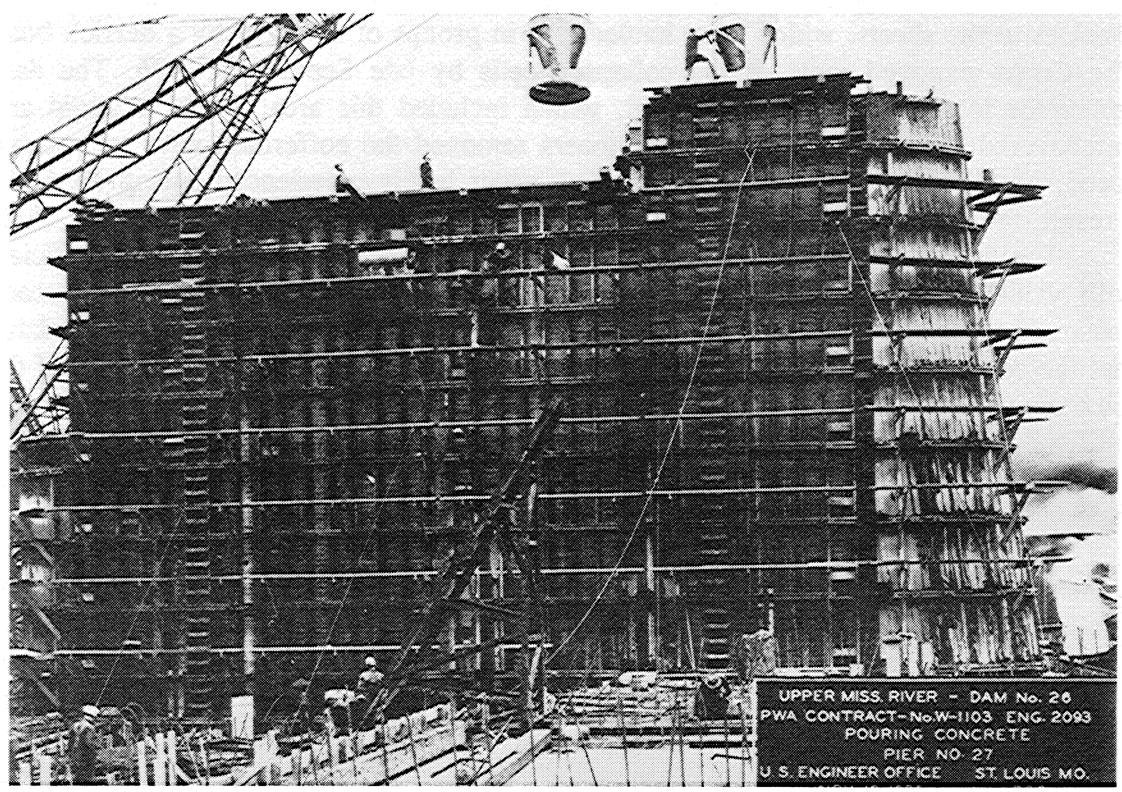
W.F. Goodson, one of the engineers engaged in the raising of the battleship Maine and then assigned to the Buffalo District of the Corps of Engineers, assisted in the removal effort. Dredges removed the sand atop the collapsed cells. Divers then attached shackles to the sheets, which were hauled free in groups of 12 to 20 by a derrick boat. The Corps removed most of the collapsed cells by late September 1936. The dam contractor located his third cofferdam, which included this area, so as to avoid any unrecovered sheets. The Corps of Engineers removed the cofferdam with remarkable speed, partly because of the abnormally low water levels experienced during 1936. As a result, the dam contractor was able to access the area on schedule in November 1936.

The failure of Griffiths & Son to complete their contract provided Corps officials with valuable information regarding the appropriate manner in which to approach construction projects of this magnitude. Griffiths & Son's low bid virtually mandated that the company use the most efficient equipment and operational plan available if the job were to be profitable. Instead, Griffiths & Son developed a plan based on equipment on hand rather than the most suitable and efficient. Likewise, the firm, though inexperienced in river construction, had made no attempt to secure the services of an experienced superintendent.

Griffiths & Son also failed to take into account the complexities of the job. The company's inattention to dredging the subgrade within the cofferdam required the removal of large amounts of fill by dragline which, along with inadequate control of pumping, delayed pile driving. Griffiths & Son also failed to adequately plan the layout of the piling, which delayed preparation of the foundations at the gate bay areas and, consequently, delayed concrete placement and the erection of the miter gates. Corps engineers also estimated that if the contractor's crews had worked 24 hours a day on the main lock cofferdam, the job could have been finished by April 1935, 5 months ahead of the actual completion date. In turn, completion of the main lock in April would have permitted completion of the auxiliary lock cofferdam prior to the onset of river ice, thus avoiding the disastrous cofferdam failure.[22]

Construction of Dam No. 26

Upper Mississippi Valley Division Senior Engineer A.F. Griffin signed the construction drawings for Dam No. 26 in December 1934. Griffin and the UMVD team designed the 1,724-foot-long movable dam with 3 steel roller gates, each 25 feet deep and 80 feet long, and 30 submergible steel Tainter gates, each 30 feet high and 40 feet long. The engineers located the roller gates in the center of the dam, flanked on either side by 15 Tainter gates. Individual electrically-driven gear reduction units, mounted either on the roller piers or beneath the service bridge spans, raised and lowered the roller and Tainter gates respectively. The Corps also equipped the installation with a steel deck girder service bridge that extended across the entire length of the dam. A 75-ton locomotive crane was mounted on rails atop the bridge. An earthen dike, adjoining the Missouri abutment at an angle, extended nearly 900 feet to the embankment of the Missouri & Illinois Bridge & Belt Railway.



Concrete placement for Dam No. 26 was accomplished with gantry cranes and buckets, which were more efficient than the belt conveyor system used during the construction of the main lock. Construction of Dam Pier No. 27, November 1935. (U.S. Army Corps of Engineers, St. Louis District)

The Corps of Engineers received four bids for the construction of Dam No. 26. The Engineering Construction Company of Delaware was the lowest. The company was a joint venture of the George A. Fuller & Company, the Turner Construction Company, and Spencer, White & Prentis, and had been organized for the sole purpose of securing the Dam No. 26 contract. The company's bid of nearly $4.9 million was almost $200,000 less than the next lowest bid, but $650,000 above the government estimate for the job.

The Engineering Construction Company received notice to proceed in mid-June 1935, and immediately established a construction plant on the Missouri shore of the river. The member firm of Spencer, White & Prentis designed the plant. The company had recently completed Lock and Dam No. 6 at Trempealeau, Wisconsin, and was also, at the start of this contract, constructing Lock No. 3 at Red Wing, Minnesota.

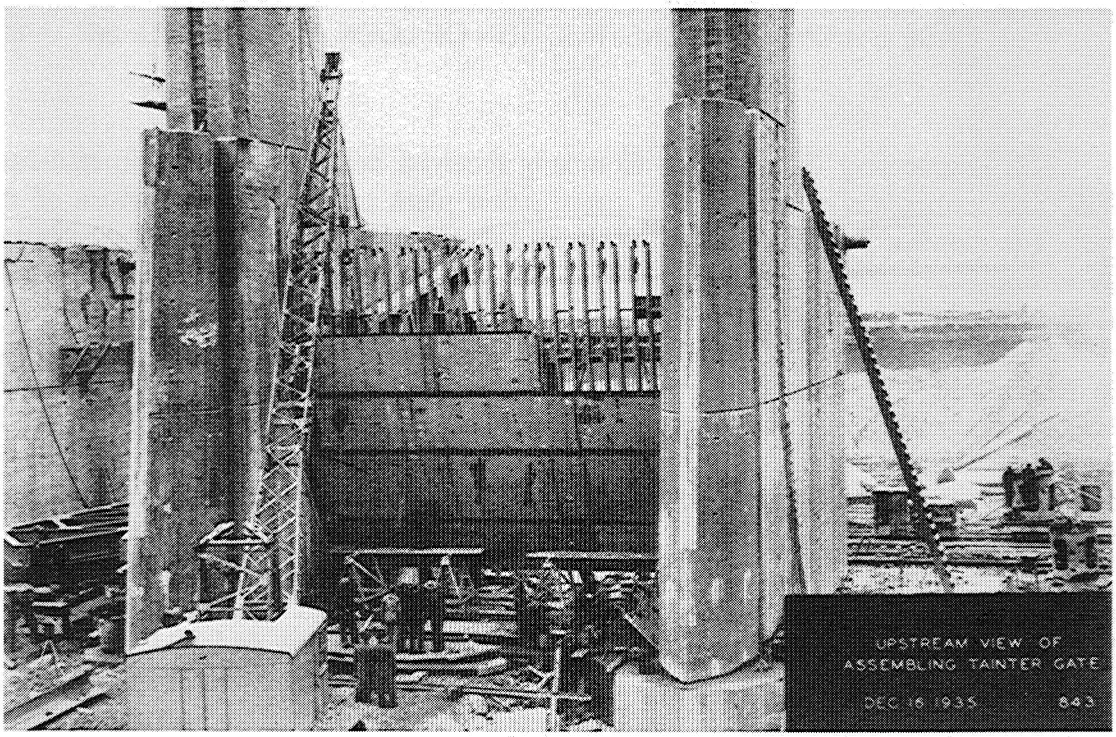
In marked contrast to the land-based construction techniques of Griffiths & Son, the Engineering Construction Company designed their entire operation according to generally accepted principles of marine construction. In addition to locally-hired labor, the Engineering Construction Company staff included between 30 and 35 experienced specialists. Again, this differed from Griffiths & Son, who had no personnel experienced in river construction.

The Engineering Construction Company constructed Dam No. 26 within three cofferdams. The first cofferdam enclosed an area that included the site of the Missouri abutment and the 12 Tainter gate bays adjacent to the abutment. In late June, workers began constructing this cofferdam, which consisted of 2 rows of interlocking steel sheet piling, ranging in length from 37 to 60 feet, spaced 30 feet apart and connected by tie rods. Sand filled the space between the two rows of sheet piling, and was bermed against both the outside and inside walls. Timber guide piling carried the templates for the steel sheet piling. The contractor completed the cofferdam after 45 working days.

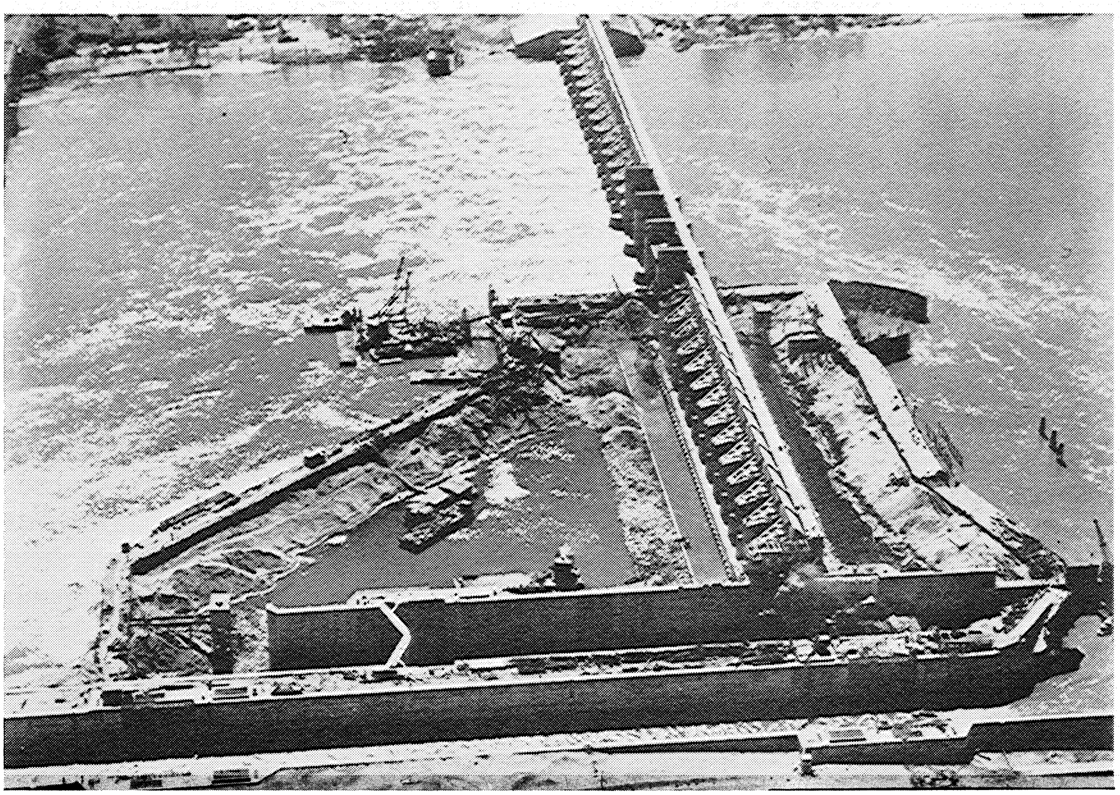
Workers drained the first cofferdam by the end of August, and began driving the dam's timber pile foundation. By mid-December, the Engineering Construction Company had driven a total of 5,100 wooden piles, an average of nearly 3 piles per hour for each of the 2 driving rigs. A continuous, 47.5-foot-deep, steel sheet-pile, cutoff wall extended across the length of the dam above the piers. The company located a second cutoff wall, 24.5 feet deep, at the downstream edge of the stilling basin. Transverse walls of sheet piling connected the upstream and downstream cutoff walls every 96 feet.[23]

Workers began placing concrete in mid-October 1935. The contractor used a floating concrete plant, which included a pair of 1.5 cubic yard Ransome mixers with accompanying scales, hoppers, and bins, to supply the concrete. The Engineering Construction Company also used a series of belt conveyors to carry the concrete over the cofferdam and into a large hopper situated on locomotive tracks. The concrete was then released into 62-cubic-foot dump buckets on flat cars. The flat cars hauled the concrete to the gantry cranes, which lifted the buckets to the point of placement. The method of concrete placement underwent minor modification during the course of construction. Piers 29 and 31 in the first cofferdam were placed in accordance with the contract specifications, which called for two separate lifts. Tests on these piers showed no fatigue or form distress, and it was determined to place the next pier continuously to full height. This proved successful and permitted elimination of the 22 to 24 hours of rest time previously required between lifts, increasing the rate of construction to 2 piers per week.

The Engineering Construction Company completed work within the first cofferdam by the end of February 1936. Workers removed the steel sheet piling by the end of



(Above) Tainter Gate Assembly on Dam No. 26, December 1935.
(Below) Aerial view of cofferdam surrounding Dam No. 26, August 1937.
(Both photographs: U.S. Army Corps of Engineers, St. Louis District)



May. This material was reconditioned for use in the second cofferdam, which had been begun in early February 1936. The second cofferdam slightly overlapped the first cofferdam, enclosing an area for the construction of six Tainter gates and the three roller gates. The Engineering Construction Company designed and constructed the second cofferdam in a similar way to that of the first, with the overlapping section used as a locking chamber for the storage of forms, cranes, and other construction equipment. The cofferdam was closed in mid-May 1936, despite a failure of the guide piling and trestle work of the upper arm at the beginning of the month. Construction crews drove the last steel sheet piling during early June.

The contractor began to dewater the second cofferdam in mid-June 1936. A unique feature associated with this process was the use of a floating crane and pile driver within the cofferdam. These rigs spread stone for the inside berms and drove the piles for the gantry crane trestles prior to the completion of dewatering. The Corps of Engineers estimated that this innovation saved 10 to 15 days of work. The contractor's crews began driving piles in the second cofferdam in late June 1936; the first concrete placement occurred about a month later.

The American Bridge Company began erecting the Tainter gates in early August, and a month later started erecting the three roller gates. By the end of October, work within the second cofferdam was completed. The cofferdam was removed by early December. The principal change in procedures between the first cofferdam and the second stemmed from the American Bridge Company's full use of the service bridge for both the delivery of steel into the cofferdam and as a base for the guy derrick used to erect the steel.[24]

The American Bridge Company was the subcontractor for steel fabrication and erection. The firm established its field office at the site in mid-October 1935, and began erecting steel eye bar assemblies in late November. The company had originally planned to transport structural steel members into the cofferdam by means of the service bridge. However, earth slides along the Missouri abutment delayed the construction of the service bridge, forcing American Bridge to build a temporary trestle. As a result, the American Bridge Company did not begin erecting the service bridge until January 1936. However, to prevent delays, members for the Tainter gate A-frames were brought by rail onto the lower arm of the cofferdam, and moved into the gate bays by gantry cranes. American Bridge Company crews erected the steel within the bays. United Construction Corporation crews placed all the reinforcing and embedded anchorage assemblies for the Tainter gates. The trunnion pins, on which the gates moved, were placed and aligned by American Bridge Company crews, and the enclosing stirrups later pre-stressed, under a 500,000-pound load, to the embedded anchorage assembly.

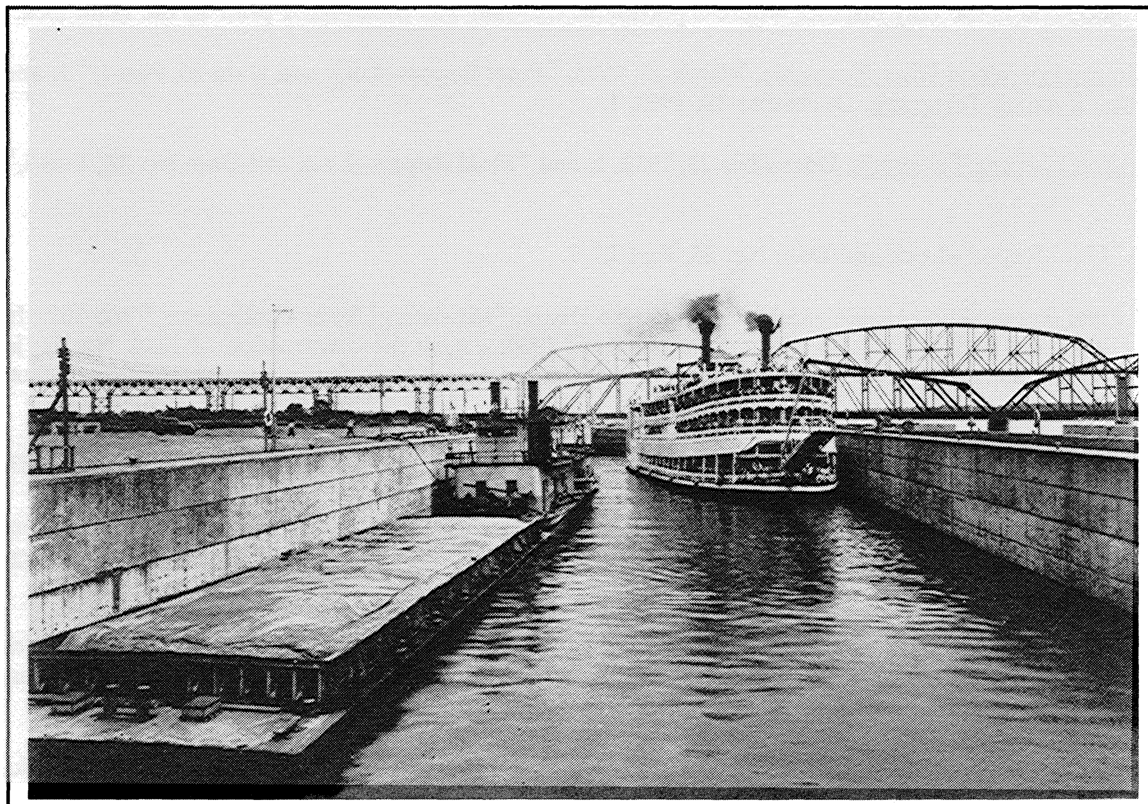
The American Bridge Company had the roller gates partially shop-assembled at its plant, and shipped to the construction site for erection. The Tainter gates appear to have been assembled in the field. The American Bridge Company also had the roller gate operating machinery shop-assembled and erected atop the piers prior to the construction of the poured-in-place operating houses. Falsework supported the gate sections during the erection process. The company erected the end sections first, and carefully positioned them into their precise operating positions. Crews then assembled the central section, which was bolted to the ends. The entire gate was aligned, the apron placed, the gate riveted and realigned. The inclined racks in the pier recesses were lined, leveled, and grouted into place. After the grout set, workers connected and adjusted the hoist chain, rolled up the gate, and dismantled the falsework. The gate was then rolled down into its closed position so that the Corps could check the alignment of the seal. Finally, the end shields were straightened and realigned into their final position.[25]

Construction of the Central Control Station, Dam No. 26, September 1937. (U.S. Army Corps of Engineers, St. Louis District)

Engineering Construction Company crews began building the third cofferdam in late September 1936. This cofferdam enclosed the remainder of the dam area, as well as the site of the auxiliary lock. In mid-November, the contractor closed the upper arm of the cofferdam without incident. The lower arm was closed approximately a month later and dewatering operations started immediately. Work in the third cofferdam progressed in the same fashion as previously described. The contractor's employees began driving piles in mid-December 1936, and essentially completed the job by the end of April 1937. Concrete placement began at the end of January 1937. The American Bridge Company began erecting Tainter gate steel in mid-April and, at one point, managed to complete two gates per week.[26]

The Corps of Engineers located the central control station for Lock and Dam No. 26 on the river wall against the dam. Based upon their experiences at other Mississippi River sites, Corps engineers found that reinforced concrete tended to crack and check in thin building walls, permitting objectionable condensation on the building's interior walls. As a result, the Corps redesigned the control station at Lock and Dam No. 26 as a brick and tile building with a structural steel frame. The Corps constructed the control station between July and December 1937.[27]

Work within the third cofferdam was completed in September 1937. Work crews finished removing the sheet piling by the end of December 1937. On January 21, 1938, the Federal Government declared the contract completed. In its final report on the project, the Government praised the experience and efficiency of the member firms of the Engineering Construction Company. The experience gained during work on Dam No. 26 convinced engineers in the St. Louis District that planning and experience were as important, if not more so, than price on such a large-scale construction project. All future work in the district was accomplished by firms experienced in river construction.[28]



With the completion of the 9-Foot Channel Project, the Corps of Engineers made the Mississippi River fully navigable, providing for efficient transportation of materials and people. Steamships and Barge in Main Lock No. 26, June 1938. (U.S. Army Corps of Engineers, St. Louis District)

CHAPTER EIGHT NOTES

1.Dobney, River Engineers, 150.

2."Mississippi River Lock and Dam No. 17: Final Report Construction," Vol. I: "Introduction, Lock, and Temporary Buildings" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, March 1938), 3, RG77, Entry 81, Box 666, NACB; and H. Doc. 137, 1-10.

3.H. Doc. 137, 120.

4.David W. Moore and Frederick J. Dobney, "Engineers, Environmentalists, and the Replacement of Locks and Dam No. 26: A Study in Passion, Politics, and Principle" (n.d., photocopy in the files of the Office of History, U.S. Army Corps of Engineers, Fort Belvoir, Virginia), 24-25.

5.Alton (Illinois) Evening Telegraph, September 13, 1933, 1; September 15, 1933, 1; and September 16, 1933; and Journal of Wood River Township, March 13, 1975 (clipping file at Hayner Public Library, Alton, Illinois).

6.Mudd, "Locks and Dams No. 26," 2.

7.Lock and Dam No. 26R, which opened in 1990, is not, technically, part of the original 9-Foot Channel Project, and is the only instance where a portion of the dam was constructed prior to the main lock.

8.Journal of Wood River Township, March 13, 1975; "Final Report--Lock and Dam 26, Part I," 1; and Alton Evening Telegraph, December 19, 1933, 1.

9.Alton Evening Telegraph, December 23, 1933, 1; and "Final Report--Lock and Dam No. 26, Part I," 8.

10."Final Report--Lock and Dam No. 26, Part I," 7.

11.Final Report Lock 11, 60; and McCormick and Dixon, "Mississippi River Cofferdams," 105-107. In the Rock Island District, cofferdams failed in April 1934, during the construction of Lock No. 21; in April 1936, during the construction of Dam No. 11; and in January 1938, during the construction of Dam No. 17.

12.McCormick and Dixon, "Mississippi River Cofferdams," 106; and Johnson, Louisville District, 183.

13.Alton Evening Telegraph, January 9, 1934, 1; and January 22, 1934, 1; "Final Report--Lock and Dam No. 26, Part I," 9, 13-14; and E.P. Ketchum, "Removing a Collapsed Cofferdam," The Military Engineer, 29 (May-June 1937): 203.

14."Final Report--Lock and Dam No. 26, Part I," 29-30; and Carl Stopp, "Report of Main Lock Cofferdam Twin Locks No. 26, November 1934," 2-5 (on file at St. Louis District Office, U.S. Army Corps of Engineers).

15.McCormick and Dixon, "Mississippi River Cofferdams," 105-108; "Final Report--Lock and Dam No. 26, Part I," 31; and Stopp, "Main Lock Cofferdam," 5-6.

16.Lois Craig, et al., 210-214; and "Final Report--Lock and Dam 26, Part I," 63-64.

17."Final Report--Lock and Dam No. 26, Part I," 35-38; and Mudd, "Locks and Dam No. 26," 4. Concrete piles appear to have been used at both Lock No. 26 and Lock No. 25, the two pile-founded lock installations constructed in the St. Louis District during the 1930s. The concrete piles were placed in areas that supported heavy loads, principally at the edges of the lock walls and at the junctures between the walls and the miter gate sills. The installations constructed in the Rock Island and St. Paul Districts during this period do not appear to have utilized concrete piles.

18."Final Report--Lock and Dam No. 26, Part I," 39.

19.By the 1880s, engineers in France had used concrete construction for shore protection, and American engineers had used it to build fortifications. Marshall learned about locks and dams when in charge of the Fox and Wisconsin Rivers prior to 1888. The Corps began building the locks, dams, and canals along the Fox in 1872 under Colonel David C. Houston and completed it in 1904, by which time it had built 18 new locks, 9 composite locks, and 13 canals. Prior to 1888, Marshall also experimented with a method of pouring concrete walls when he worked on a project to protect Chicago's Lincoln Park lakefront. He adapted this system to lock construction on the Illinois and Mississippi (Hennepin) Canal Project. The methods and machines he and his assistants developed for the Hennepin project became standard industry practice and helped revolutionize American building practices. Even before Marshall's Hennepin Canal structures were complete in 1908, other Corps officers also built poured concrete locks. The 10 locks and dams designed between 1896 and 1898 under Lieutenant William L. Sibert for the White River in Arkansas included poured concrete locks. Subsequently, while serving as Pittsburgh District Engineer (1902-1905), Sibert served as a member of the Isthmian Canal Commission. There, Sibert was instrumental in carrying concrete lock construction into the Panama Canal designs. Sibert also served as a member of the Special Board of Engineers headed by Colonel Daniel Lockwood that chose concrete construction for the design of the new Ohio River locks in 1905-1906. While the Ohio River locks were being designed, Hugh L. Cooper, working closely with Montgomery Meigs, designed the Keokuk Lock, the first Upper Mississippi River lock in the Rock Island District built of concrete. Annual Report 1981, 2651; Merritt, Creativity, Conflict and Controversy, 257; Tweet, Rock Island District, 163-166; and Yeater, "Hennepin Canal," Section 8:12-13.

20."Final Report--Lock and Dam No. 26, Part I," 14, 40-41, 46-51.

21.Roberts "Canalizing for 9-ft. Navigation" 324; Daley, "Canalization of the Upper Mississippi," 105; and Gross and McCormick, "Upper Mississippi River Project," 314.

22.Ketchum, "Removing a Collapsed Cofferdam," 203-206; and "Final Report--Lock and Dam No. 26, Part I," 52-62.

23."Final Report--Lock and Dam No. 26, Mississippi River, Alton, Ill., Part II--Dam/Auxiliary Lock" (St. Louis: U.S. Army Corps of Engineers, St. Louis District), (hereafter referred to as Final Report--Lock and Dam No. 26, Part II), 1, 8, 26, 30-31, 38-39, typescript draft on file at St. Louis District Office; and Mudd, "Lock and Dam No. 26," 4.

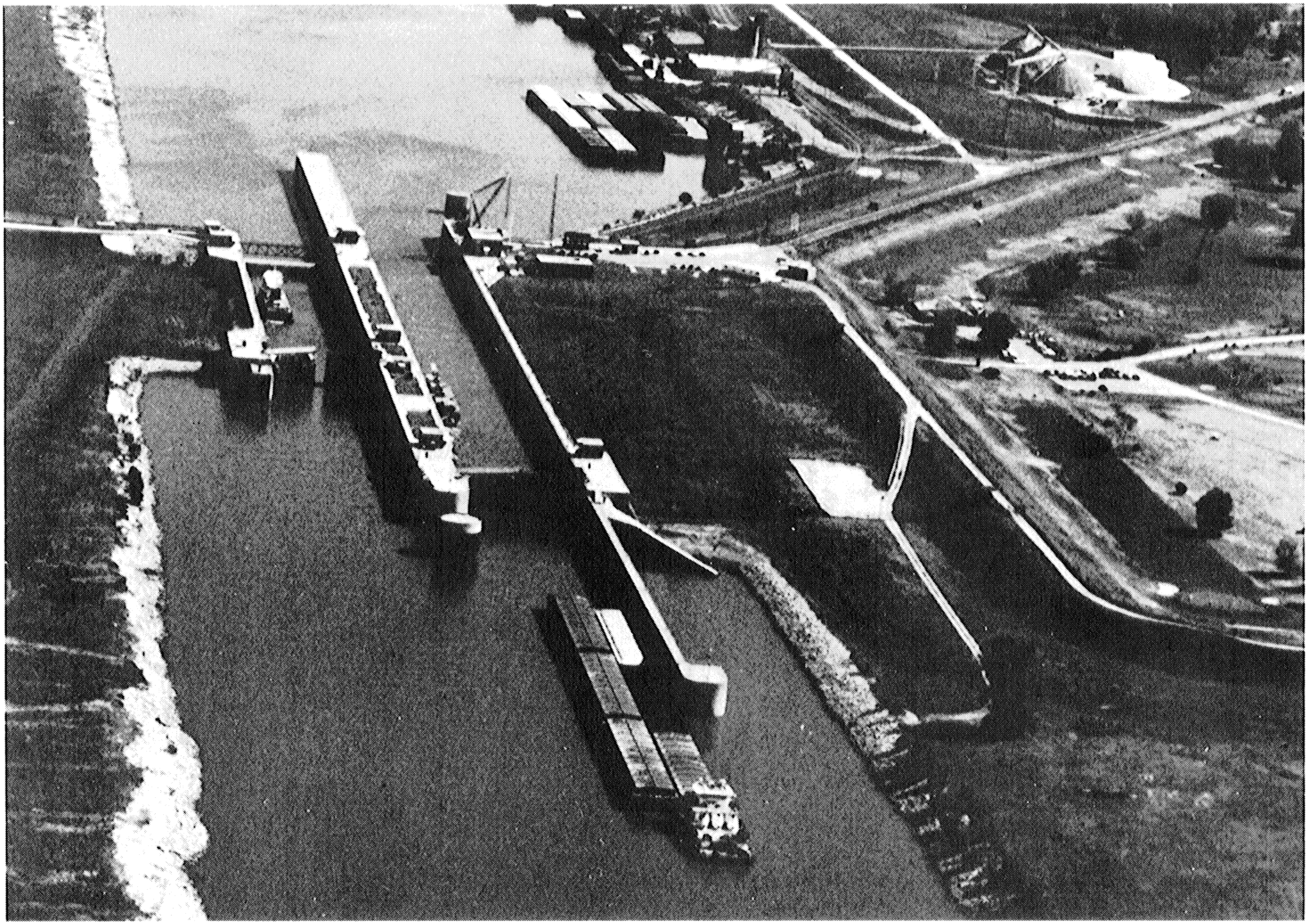
24."Final Report--Lock and Dam No. 26, Part II," 9, 31, 40-41, 45-48.

25."Roller-Gate Dam Erection," 412-414.

26."Final Report--Lock and Dam No. 26, Part II," 32-34, 38, 48.

27.Ibid., 49.

28.Ibid., 10, 50.



Lock No. 27, located at the end of the Chain of Rocks Canal, was the first major addition to the 9-Foot Channel Project. Lock and Dam No. 27 is unique in the 9-Foot Channel Project system because it is the only instance in which the lock and dam are not at the same location. Dam No. 27, also known as the Chain of Rocks Dam, is in St. Louis. The locks are five miles downstream at Granite City, Illinois. (U.S. Army Corps of Engineers, St. Louis District, c. 1980)

CHAPTER IX

The 9-Foot Channel After World War II

The Corps of Engineers constructed the majority of the 9-foot channel structures along the Upper Mississippi River between 1930 and 1940. However, several locks and dams were not constructed until after World War II. While these later structures cannot, technically, be considered part of the original 9-Foot Channel Project, their design and construction reflect the continuing evolution of river engineering and navigation on the Upper Mississippi.

Lock No. 27, Chain of Rocks Canal, and Dam No. 27

After 1940, only a single impediment prevented the maintenance of a dependable and reliable 9-foot channel extending from New Orleans to St. Paul, and up the Ohio to Pittsburgh. Known as the Chain of Rocks Reach, this obstruction was a 17-mile series of rock ledges that began just north of St. Louis. In two locations, these ledges extended completely across the channel. The ledges acted as submerged dams, causing a sharp increase in the slope of the river. This, in turn, increased the velocity of the current, making the Chain of Rocks extremely difficult and dangerous to navigate. At extreme low water, the navigable depth of this stretch of the Upper Mississippi River was often reduced to as little as 5.5 feet, preventing full use of the 9-foot channel that was available above and below the Chain of Rocks Reach.[1]

Proposals to construct a canal to bypass the Chain of Rocks Reach originated as early as 1904, all without result. It was not until October 1938 that Congress requested the Chief of Engineers to recommend a plan for the improvement of the Chain of Rocks Reach. In its final report, submitted in December 1938 and printed as House Document No. 231, the Corps of Engineers recommended construction of a bypass canal at the

Chain of Rocks. Congress authorized the project in 1939 but, because of the imminence of war, President Franklin D. Roosevelt vetoed the bill. Congress reapproved the project in March 1945, and the President signed the bill into law. The Upper Mississippi Valley Division, regaining some of the authority it had lost during the rush to turn the 9-Foot Channel Project into a public works program, designed the canal and the twin locks located near its lower end. St. Louis District Engineer Colonel Rudolph E. Smyser, Jr., oversaw the construction.[2]

Lock No. 27 and the Chain of Rocks Canal constituted the first major addition to the original 9-Foot Channel Project, and the final element required to secure a navigable 9-foot channel between St. Paul and New Orleans. As designed by the Corps of Engineers, the canal measures 550 feet wide at the top, 300 feet wide at the bottom, and has an average depth of 32 feet. The twins locks are located at the southern end of the 8.4-mile Chain of Rocks Canal.

The Corps of Engineers constructed the lock installation between 1947 and 1953. The main lock measures 110 by 1,200 feet, and the auxiliary lock is 110 by 600 feet. The lock walls are as much as 92 feet tall, and are of monolithic reinforced concrete construction founded on bedrock. To flood and empty the lock chambers, Corps engineers located longitudinal culverts in the base of the lock walls. However, unlike the earlier installations, where the culvert intakes were located in the lock walls, the intake ports of the new locks are located in the floor immediately above the upper gates. The Corps also redesigned the arrangement of the discharge ports. Instead of placing large ports in the lock walls below the lower gates, the engineers designed the new locks to include a complex discharge manifold that releases water through the floor of the lock structure below the lower gates. The manifold greatly reduces the turbulence associated with the water emptying from the lock chamber.[3]

The Corps equipped the locks with electrically-operated miter gates, balanced on steel pintles, similar to those on the locks constructed in the 1930s. The gates are extremely large, each leaf of the main lock gate measuring 61 feet across, 72 feet tall, and weighing 170 tons. The auxiliary lock gates are 43 feet tall and weigh 140 tons per leaf.

The upper gates depart from previous practice on the Upper Mississippi. The Corps located the locks at the end of the Chain of Rock Canal, requiring ice to pass through the lock chamber during the winter. Miter gates cannot operate against an appreciable head of water, as required under these circumstances, so Corps engineers designed double-leaf, vertical-lift upper gates. When the lock is empty and the lower miter gates are fully opened, the downstream leaf of the lift gate may be lowered, much like a double-hung window, until it nests behind the upstream leaf. Ice can then pass freely through the lock chamber.[4]

In its design of the locks, the Corps made several other departures from earlier practice. Instead of the single, central, control station used at earlier 9-foot channel sites, Corps engineers designed No. 27 with six separate control stations. The Corps located these stations at both ends of the east and intermediate lock walls, the upper end of the west wall, and the mid-point of the intermediate wall. Emergency bulkheads, placed by stiffleg derricks, are provided to close off the upper gate bays of the locks for repairs. Dewatering pumps, located within the lock walls, are then used to completely empty the lock chambers.[5]

The Corps constructed Dam No. 27, also known as the Chain of Rocks Dam, to provide additional water in the pool below Lock and Dam No. 26. Congress authorized the construction of Dam No. 27 in 1958. In 1964, the Corps completed the dam, which assures a minimum depth of 10.5 feet of water over the lower gate sills at Lock No. 26. Designed and constructed by the St. Louis District, the fixed-crest rock dam is 3,240 feet long, and constitutes the first, complete, non-navigable barrier across the Mississippi.[6]

Lock No. 19

Congress authorized Lock No. 19 as part of the original 9-Foot Channel Project legislation. However, because of design changes, the project required new congressional approval in 1952 and was not completed until 1957. Lock No. 19 is located at the site of the Keokuk and Hamilton Water Power Plant near Keokuk, Iowa. The Keokuk and Hamilton Water Power Company, now the Union Electric Power Company, constructed the power plant between 1910 and 1914, and the installation included a lock and dam. Although the Corps incorporated the existing lock and dam into the 9-foot channel system, it was also authorized to build a new lock at the site.

Corps engineers began planning for the new lock in 1930, but encountered serious problems concerning where to locate it without interfering with the operation of either the powerplant or the dry dock. The Corps finalized the lock's location in 1937, by which time all the structures in the Rock Island District were already either completed or under construction. At this point, however, Corps engineers began to tinker with the design of Lock No. 19. Because of the 40-foot lift at Keokuk, the engineers considered deviating from the standard 110 by 600 foot design.

In 1945, however, even before specifications and model studies had been completed for the proposed lock, the Rock Island District recommended that Lock No. 19 be expanded to a length of 1,200 feet. The larger size would allow the new, longer tows to pass through the lock in one piece, rather than being broken up into lockable pieces, as was becoming routine at the other locks in the 9-foot channel system. In 1952, Congress authorized the Corps to build the lock at this enlarged size.

In the design of Lock No. 19, the Corps of Engineers utilized much of the technology developed in the 9-Foot Channel Project of 1930-1940. However, the Corps also incorporated newer technologies that had developed in the 10 years since the completion of the original system. Other than the larger size, the most important difference is found in the gate design. The upper gates of Lock No. 19 are single leaf, hydraulically-operated gates, and in no way resemble the lock gates built as part of the original project. There are two gates and either one functions to hold back the upper pool, although the innermost gate is considered to be the main gate. Corps engineers designed the lower gates in a more standard fashion, but used a modern form of steel framing based on solid "L" irons. Another unique feature of Lock No. 19 is its system of underground tunnels that run under the walls and chamber of the lock. These tunnels provide ready access to the electric cables that they house, as well as being a means to get to the other side of the lock chamber.[7]

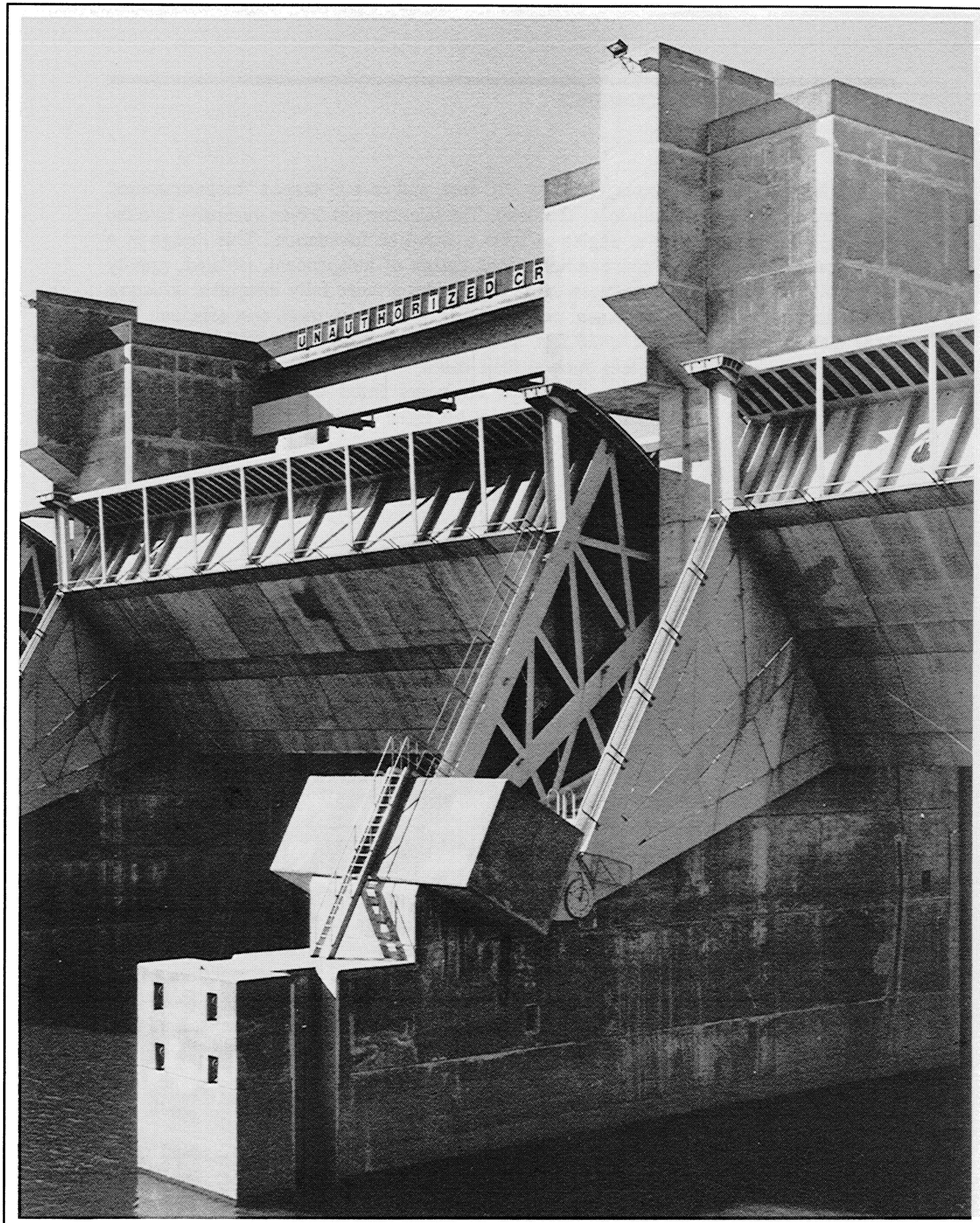
Lock and Dam No. 26R

The most recent alteration to the Upper Mississippi River 9-foot channel system occurred in 1990, when the Corps of Engineers replaced the original Lock and Dam No. 26 with Lock and Dam No. 26R, also known as the Melvin Price Lock and Dam. The administrative and political history of Lock and Dam No. 26R, located just downstream from the original installation, is reminiscent of the controversy that surrounded the 9-Foot Channel Project of the 1930s. The Government authorized Lock and Dam No. 26R in 1969, and the St. Louis District began planning the new installation in 1970. In September 1974, however, the Sierra Club, the Izaak Walton League, and the Western Railroad Association filed lawsuits to halt work on the project. The lawsuits charged that the environmental analysis of the project was inadequate and that the Congressional authorization, under the Rivers and Harbors Act of 1909, applied only to maintenance work.[8]

The environmentalists feared that the new facility represented an effort to promote a 12-foot channel on the Upper Mississippi River. In fact, the design of Lock and Dam No. 26R met the construction requirements for a 12-foot channel as outlined in a 1972 Upper Mississippi River Comprehensive Basin Study. But that same study had also declared a 12-foot channel economically infeasible above the mouth of the Illinois River. Echoing the concerns of the 1930s, railroad officials opposed Lock and Dam No. 26R because they believed a government-owned, river improvement was unfair competition.[9]

The draft supplemental environmental impact statement for Lock and Dam No. 26R was issued in June 1975. In February 1976, the Board of Engineers for Rivers and Harbors, at the request of the Chief of Engineers, recommended construction of the new lock and dam. This recommendation was forwarded to Congress in July 1976, and signed into law by President James Carter in October 1978. The Corps began constructing Lock and Dam No. 26R in 1980; work on the project was estimated to cost approximately $900 million.[10]

The Corps of Engineers designed Lock and Dam No. 26R to include all the basic elements of the first 9-foot channel installations. The biggest difference is the enormous scale of the project. The Tainter gates, vertical lift gates, and other components at the new installation dwarf those of the earlier complexes. Still, despite the size difference, the movable dam, navigation lock, and submersible dikes connecting the structure to shore are all readily identifiable. The construction process also closely resembled the construction of the 9-Foot Channel Project of the 1930s.



Although they operate in essentially the same way, the new Tainter gates on Dam No. 26R are enormous compared to those of the now-demolished Dam No. 26. The Tainter gates on Dam No. 26R are 110 feet long, compared to the 45-foot-long Tainter gates on the original structure. (John P. Herr, John Herr Photography)

The main lock measures 1,200 by 110 feet, and is a U-shaped "megastructure" supported on steel H-piles up to 81 feet long. The piles are not driven vertically into the riverbed, but are battered at angles to form a web-like foundation. This design is a significant departure from the traditional lock design of independent, isolated, gravity side walls with a base slab between them. It provides a more fully integrated structure that is less susceptible to movement over time and, ultimately, more cost efficient. The base slab of Lock No. 26R is 20 feet thick at each end, tapering to 15 feet in the middle. The side walls, 40 feet thick at their bases, rise more than 60 feet above the base slab. As with Lock No. 27, Corps engineers fitted the new structure with downstream miter gates and upstream vertical lift gates, although the latter have three leaves rather than the two at Lock No. 27.[11]

The Corps of Engineers conducted an extensive program of measurement, observation, and computer testing at Lock No. 26R. A host of monitors, sensors, lasers, and computers measured and analyzed virtually every aspect of the project's design and construction. This work resulted in the refinement of a host of details, including the design and construction of cofferdams, the mixing and distribution of concrete, and the placement of guidewalls. Engineers analyzed each section of the structure in terms of as many as 30 different combinations of loads. Staff members at the Corps' waterway experiment station at Vicksburg, Mississippi, conducted research on concrete creep and shrinkage, projected over the life of the structure, and determined that these conditions may impose greater force and stress upon the structure than other loads. Perhaps the most widely applicable benefit to emerge from the testing program was the discovery that the steel sheet piling used to construct cofferdams did not have to be driven into the riverbed as deeply as previously thought. Driving the piling to a shallower depth significantly reduced costs, and increased the amount of piling that could be reused upon the removal of the cofferdam.[12]

The Corps also constructed the lock guidewalls at Lock No. 26R in a non-traditional manner. Construction crews built the 1,500-foot upstream and 855-foot downstream guidewalls "in the wet," rather than following the usual method of erecting a cofferdam and working "in the dry." For the downstream wall, Corps workers drove a series of sheet pile cells into the river bottom. H-beam piles were driven through the center of each cell to increase its stability. Workers then placed tremied concrete, a form of concrete capable of being placed underwater, into each cell, providing a foundation for a series of precast concrete beams, each weighing 225 tons, that were stacked atop the cells by a massive heavy-lift cantilever crane riding on a runway girder.[13]

Upper and Lower St. Anthony Falls Locks and Dams

In 1937, Congress authorized a 4.6 mile extension of the 9-foot channel at its upstream end and 2 additional complexes were built in Minneapolis: the Lower St. Anthony Falls Lock and Dam, and the Upper St. Anthony Falls Lock and Dam. The Corps built these two structures, respectively, in 1956 and 1963. The construction of these complexes, also known as the Upper Minneapolis Harbor Development, extended the 9-foot channel over the St. Anthony Falls. Below the St. Anthony Falls, the narrow gorge of the Upper Mississippi River only allowed for a relatively small river terminal. By extending the 9-foot channel, the Upper Minneapolis Harbor Development project permitted the construction of larger and more suitable river terminal sites above the falls.

St. Anthony Falls has a fall of 74 feet, and had historically been used to furnish waterpower for sawmills and flour mills in the area. In order to ascend the falls, the Corps of Engineers needed a 25-foot lift at the lower lock, and a 49.2-foot lift at the upper lock. The Lower St. Anthony Falls Lock and Dam project also replaced the original Northern States Power Company Dam, which had been built in 1897. Corps engineers equipped the new dam with Tainter gates, 19 feet high and 56 feet long. The lock measures 56 by 400 feet, and has a lift of 25 feet.

The Upper St. Anthony Falls Lock and Dam complex includes a fixed concrete dam. The dam was built in 1951, when an existing timber dam was destroyed by flood. The timber dam had been constructed in the 1870s in an effort to protect the St. Anthony Falls from upstream progression. Since the concrete dam was in place, the Corps of Engineers only needed to construct a navigation lock. But, with a rise of 49.2 feet, the lock was the highest lift on the river and an engineering challenge that cost over $18 million to build. Like the lower lock, the Upper St. Anthony Falls lock measures 56 by 400 feet.[14]

CHAPTER NINE NOTES

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2.Dobney, River Engineers, 115; and Smyser, "Chain of Rocks," 16.

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4.Smyser, "Chain of Rocks Project," 17; "Biggest Lock on the Mississippi," Engineering News-Record, 145 (October 5, 1950): 30; and Mississippi River Lock & Dam No. 27, Locks--Lift Gate Machinery--General Arrangement, Drawing No. M-L 27 22/51 (April 1947).

5.Mississippi River Lock & Dam No. 27, Locks--Buildings--Key Plan, Drawing No. M-L 27 70/0 (April 1947); Unwatering & Drainage Equipment--General Arrangement, Drawing No. M-L 27 36/1 (April 1947); and Lock Bulkhead Handling Equipment--General Arrangement, Stiffleg Derrick, Hoist & Pickup, Drawing No. M-L 27 35/1 (April 1947).

6.Mudd, "Locks & Dam No. 26," 9; and Dobney, River Engineers, 116.

7."Completion Report on the Construction of New Lock 19, Mississippi River" (Rock Island: Corps of Engineers, Rock Island District, March 1958), 3; and Tweet, <u>Rock Island District</u>, 274-278.

8.Ibid., 150-152; Colonel Thorwald R. Peterson, "Replacement for Locks and Dam No. 26," <u>The Military Engineer</u>, 66 (1974): 287; and Carol Koch, "Old 26--An Economic Bottleneck," <u>Soybean Digest</u>, 37 (December 1976): 6.

9.Dobney, <u>River Engineers</u>, 152; and Merritt, <u>The Corps, Environment, and Mississippi Basin</u>, 67-68.

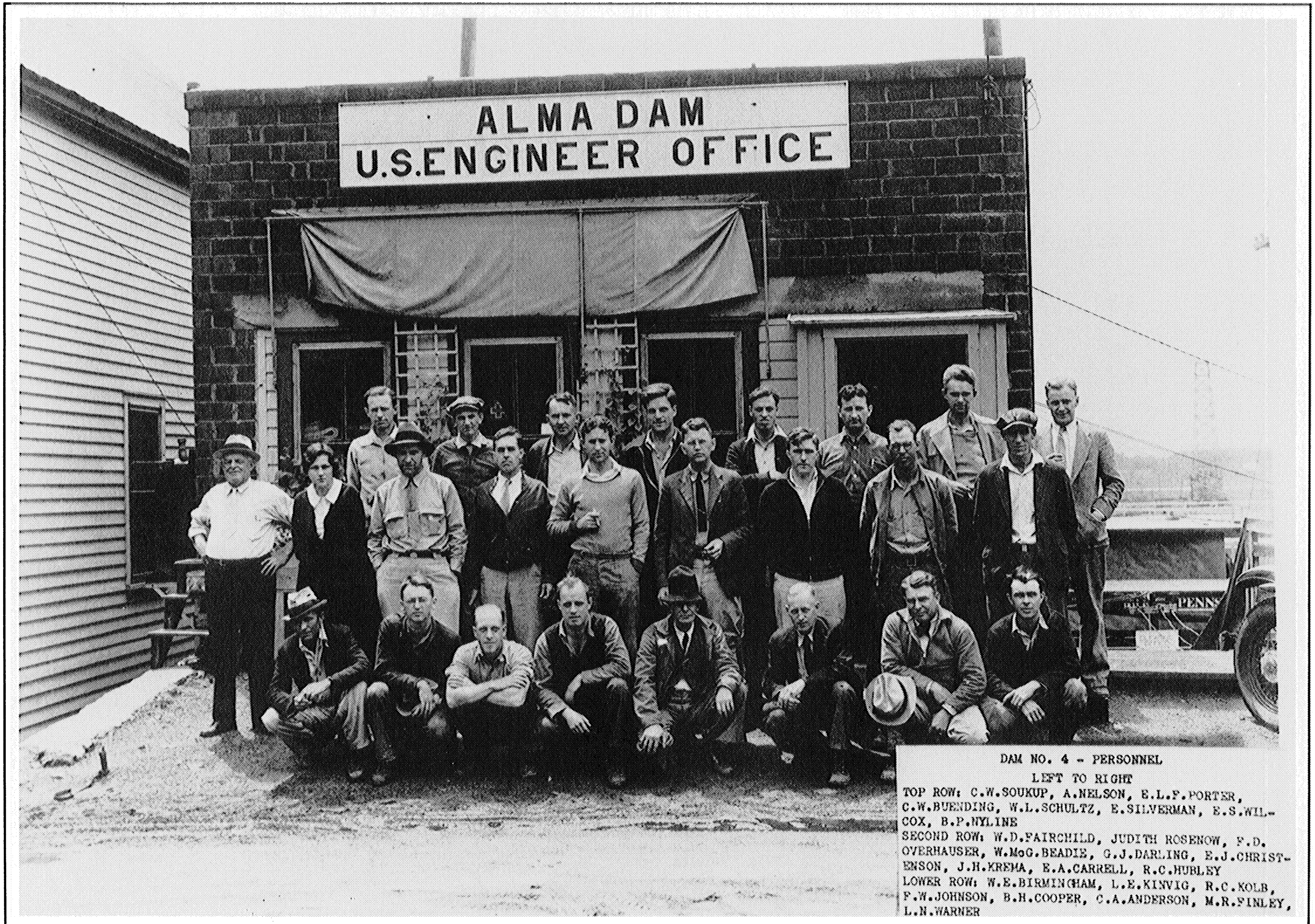
10.Colonel Leon E. McKinney, William R. Sutton, and Jean-Yves Perez, "Locks and Dam No. 26: Rehabilitation Versus Replacement," <u>The Military Engineer</u> 72 (1980): 110-111.

11.Soast, "Navigation Lock," 38; and Peterson, "Replacement of No. 26," 287.

12.Soast, "Navigation Lock," 38-40; "Barge Bottleneck Uncorked," <u>Civil Engineering</u> (January 1987); and "Girder-Mounted Crane Cuts Guidewall Costs," <u>Highway and Heavy Construction</u>, 130 (January 1988): 52-55.

13."Girder-Mounted Crane," 52-55.

14.Martin Nelson, "The St. Anthony Falls Upper Harbor Project," copy in the files of the St. Paul District Office, U.S. Army Corps of Engineers; Francis E. Mullen, "St. Anthony Falls Navigation Project," <u>Journal of the Construction Division, Proceedings of the American Society of Civil Engineers</u>, March 1963; and Jon Gjerde, "St. Paul Locks and Dams."



Personnel at Lock and Dam No. 4, located at Alma, Wisconsin, c. 1936. (American Heritage Center, University of Wyoming)

CHAPTER X

The Locks and Dams--and Those Who Built Them

The Upper Mississippi River 9-Foot Channel is a unique engineering entity. No two lock and dam complexes on the Upper Mississippi are exactly the same. Each was shaped by its place in the technological development of the 9-Foot Channel Project. Each was also designed specifically for its location, reflecting the navigational needs and hydrological characteristics of that stretch of river. As noted by one Corps historian, the system was only as strong as its weakest link--all of the installations had to function as part of a system while, at the same time, accommodating local needs.[1]

The Upper Mississippi Valley Division designed the major elements of the 9-Foot Channel Project between 1929 and 1933. During these years, Lieutenant Colonel George Spalding headed the UMVD. William McAlpine was Head Engineer, assisted by Edwin Abbott and Lenvik Ylvisaker. In 1933, when the 9-Foot Channel Project was reshaped into a massive public employment program, the administration of the project was also reshaped. To achieve maximum employment, the Corps began working on all of the as-yet-unstarted lock and dam complexes simultaneously. So that the greatest number of tasks could be undertaken concurrently, Corps officials decentralized the project. As a result, the influence of the UMVD was greatly reduced after 1933. At the same time, the staff and activities of the St. Paul, Rock Island, and St. Louis Districts were greatly enlarged.

The UMVD, under the leadership of Spalding and McAlpine, developed prototypes for the locks and dams of the Upper Mississippi. However, many of the design and construction innovations associated with the 9-Foot Channel Project were also made by the district engineers. The districts conducted specialized testing that proved to be of great importance to the 9-Foot Channel Project. Engineers in the St. Paul, Rock Island, and St. Louis Districts frequently devised unprecedented solutions for problems presented by building a slack-water navigation system on the Upper Mississippi. New developments in one district frequently permitted, facilitated, or compelled improvements in another district.

On the following pages are outlines of the lock and dam installations on the Upper Mississippi River, as well as brief descriptions of the St. Paul, Rock Island, and St. Louis Districts. Although the Corps of Engineers did not build the locks and dams of the Upper Mississippi in numerical order, they are presented as such in this chapter. They are also presented under the districts that administered their construction.

The St. Paul District

The St. Paul District was originally in charge of constructing that portion of the 9-foot channel on the Upper Mississippi River between St. Paul to the mouth of the Wisconsin River near Prairie du Chien, Wisconsin. The district began constructing the project in 1930. By 1940, Corps workers had substantially completed eight lock and dam complexes--Nos. 3, 4, 5, 5A, 6, 7, 8 and 9--with the exception of some ancillary service elements such as lockmasters' dwellings, garages, and access roads. In 1939, the St. Paul District's duties were expanded when it took over the administration of Lock and Dam No. 10 at Guttenberg, Iowa, which had previously been under the supervision of the Rock Island District.[2]

The St. Paul District also includes four lock and dam installations that were not constructed as part of the original 9-Foot Channel Project. The authorizing act for the 9-foot channel called for the incorporation of two existing lock and dam complexes into the system. The Twin Cities Lock and Dam (1894-1932), located between Minneapolis and St. Paul, became Lock and Dam No. 1. The Hastings Lock and Dam, constructed by the Corps between 1928 and 1930, became Lock and Dam No. 2. In 1937, Congress also authorized a 4.6 mile extension of the 9-foot channel at its upstream end, and the Corps constructed 2 additional complexes: the Upper St. Anthony Falls Lock and Dam, and the Lower St. Anthony Falls Lock and Dam. The Corps built these structures, respectively, in 1963 and 1956.[3]

In 1923, Major Charles F. Williams headed the St. Paul District office, which then consisted of the barest minimum of personnel. Charles Wade was Chief Administrator. Five years later, Western Division Engineer General Thomas Jackson spearheaded an overall restructuring of the Corps' activities, including those in the St. Paul District. As a result, administrative and engineering functions were separated, and chains of command were established in the engineering division. Following the restructuring, Colonel Wildurr Willing replaced Major Williams as head of the St. Paul District. Colonel Willing, who was assisted by Military Assistant for Special Assignments 1st Lieutenant Heath Twitchell, headed the St. Paul District until 1933, at which time he was replaced by Major Dwight F. Johns. Major Johns supervised the 9-Foot Channel Project until 1937, when Captain Frank Albrecht served briefly as Acting District Head. In July 1937, Lieutenant Colonel Phillip B. Fleming replaced Albrecht. Colonel John Moreland became head of the St. Paul District in October 1939, overseeing the remainder of work done under the 9-foot channel program as of 1940.[4]

Surveyman M.L. Betzel oversaw the hired labor. Engineering responsibilities were divided into three sections. Howard M. Anderly headed Section No. One, and supervised improvements on the Upper Mississippi from St. Paul to the mouth of the Wisconsin River, as well as various improvements on the St. Croix River. Anderly also oversaw the reconstruction of Locks and Dams Nos. 1 and 2. Section No. One included an engineer, W.D. Fairchild; two assistant engineers, V.C. Funk and James R. Johnson; and a junior engineer, Elmer J. Christenson, who was assigned to Fairchild. A construction supervisor, William P. Schmoker, and a gasoline engineman, William G. Straub, also worked in Section No. One. Schmoker supervised the work of most of the surveyors, the rock quarry overseer, the dredger engineers, and other workmen.[5]

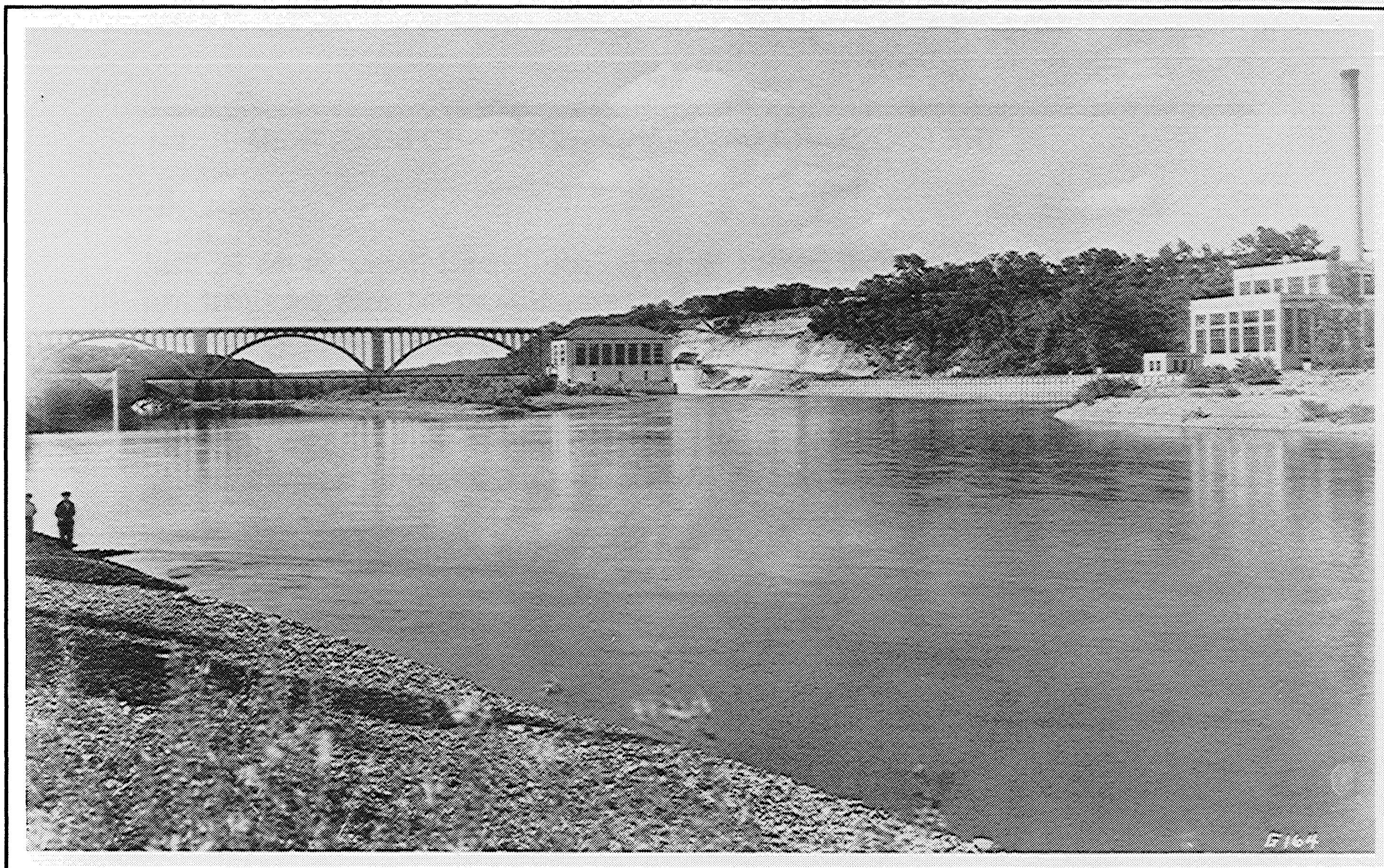
Herbert Vassant headed Section No. Two. The duties of this section included Hastings Lock and Dam flowage rights, St. Croix River permits, special investigations, and Federal Power Commission reports. Hibbert M. Hill oversaw Section No. Three, and handled flood control surveys; 9-foot channel surveys (particularly the location of dam sites and survey work); supervision of hydraulic testing at the University of Iowa; studies for the Mississippi River Survey Board; engineering and operations of reservoirs at the Mississippi headwaters; model studies; office studies; and stream measurement.

The District Engineer and Staff of the St. Paul District, c. 1936. Front row, left to right: Captain Fisher S. Blinn, Major Dwight F. Johns (District Engineer), Captain Frank Albrecht, and Captain Keith R. Barney. Second row: Edward E. Ezell and Howard M. Anderly. (American Heritage Center, University of Wyoming)

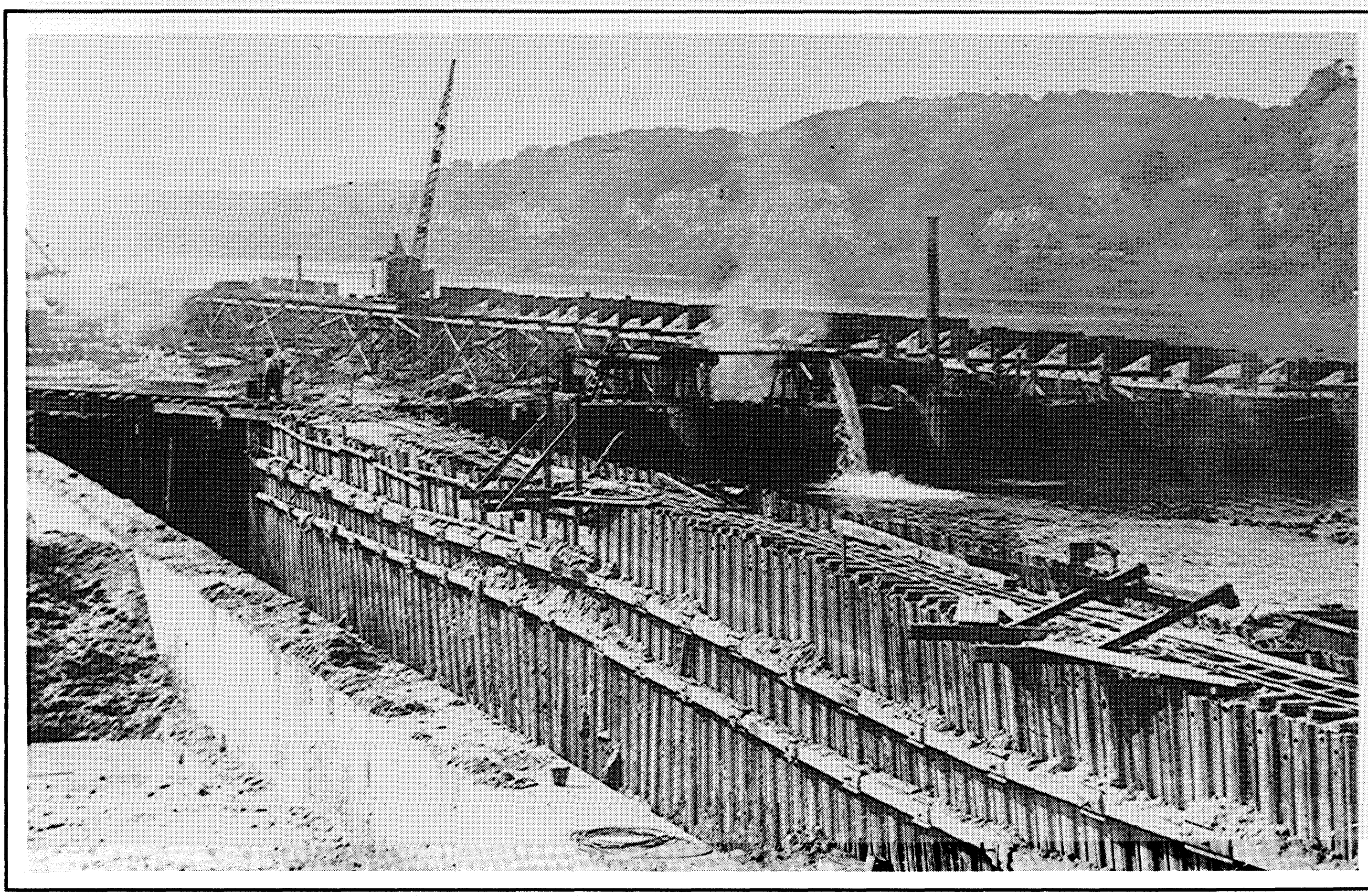
Hibbert Hill had important impacts on the 9-Foot Channel Project in the St. Paul District. A graduate of the University of Minnesota, Hill served with the Coast and Geodetic Survey before joining the Corps in 1927. Hill also taught hydraulic engineering at the University of Minnesota, where he had access to information and talented personnel. Assistant Engineer James R. Johnson, Junior Engineer Elmer Christenson, Assistant Engineer Edward F. Brownell, Assistant Engineer Henry J. Manger, Assistant Engineer Leo M. Buhr, and Assistant Engineer George O. Guesmer all received training at the University of Minnesota.

Martin E. Nelson, the district's assistant engineer in charge of hydraulic model studies conducted at the University of Iowa, was also a graduate of the University of Minnesota. Nelson had also studied at the Royal Technological Institute in Stockholm, Sweden. Since the designs of the roller gates used in the 9-foot channel had been used in Sweden, it is reasonable to assume that Nelson's expertise was a welcome asset in the St. Paul District. The unique roller/Tainter gate combination systems of the 9-Foot Channel Project were among the first known applications of their kind in the United States. Working models for these designs were handled, in part, by Nelson. Nelson's working models answered important questions concerning foundation stability, ice discharge, accurate pool levels, navigation currents, and related matters.[6]

The work carried on at the University of Iowa testing laboratories, as well as the research of civilian engineers such as Hibbert Hill and Martin Nelson, contributed significantly to the overall project in matters of gate technology and general dam design. Jerome O. Ackerman, Associate Engineer with the St. Paul District, provided much of the expertise on soil mechanics. Ackerman, who was later with the Corps' Missouri River Division, was influenced by the work of Arthur Casagrande, head of the Soil Mechanics Laboratory at Harvard University. Testing in areas such as foundation stability by technicians such as Elmer Christenson and W.W. Ralphe and their work on Lock and Dam No. 3 resulted in the use of new materials, techniques, and innovative applications, providing the basis for future progressive engineering designs. These innovations and others like them resulted in such later developments as the 80-foot Tainter gates located at Clarksville, Missouri, in the Rock Island District, and the 125-foot roller gates on the Ohio River at Gallipolis--among the largest installations of their kind ever built in the United States.[7]



(Above) Lock and Dam No. 1 with Ford Bridge in the background, ca. 1929. (Photo credit: Gibson) (Minnesota Historical Society)
(Below) Construction of Lock and Dam No. 2, ca. 1929. (Photo credit: St. Paul Daily News) (Minnesota Historical Society)



Locks and Dams Nos. 1 and 2

The 1930 authorizing act for the 9-Foot Channel Project called for the incorporation of 2 existing lock and dam complexes into the system: Locks and Dams Nos. 1 and 2.

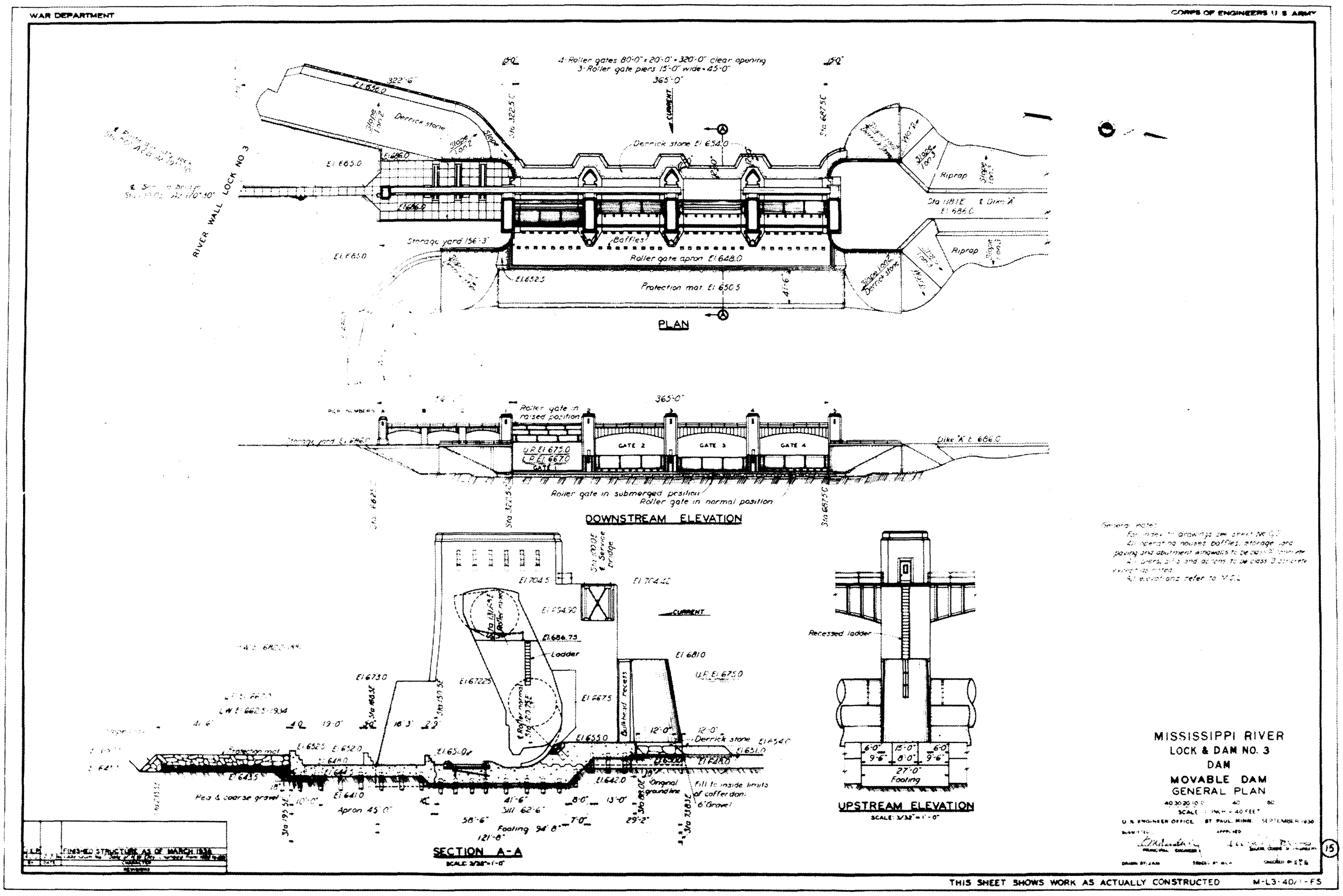
Lock and Dam No. 1
Twin Cities (Ford) Lock and Dam

Located between Minneapolis and St. Paul, Minnesota, the Corps of Engineers began constructing this installation in 1894 as part of the 5-foot channel concept. The complex was later modified during the 1907 6-foot channel project, and includes a reinforced concrete overflow dam, and 2 navigation locks that measure 56 by 400 feet. A hydroelectric plant located at the dam's east end provides power to a nearby Ford automobile factory.

Lock and Dam No. 2
Hastings Lock and Dam

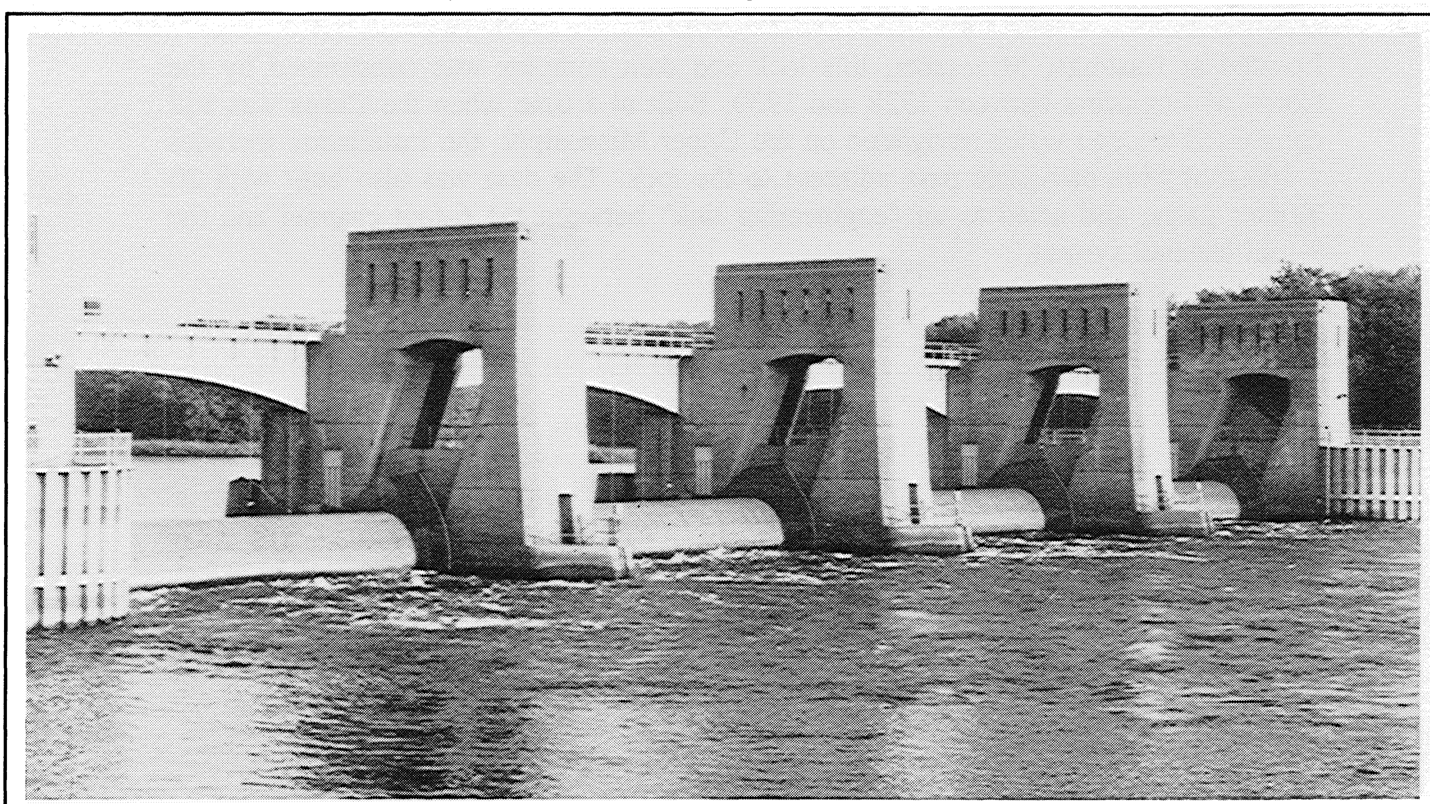
Located at Hastings, Minnesota, this lock and dam complex was constructed by the Corps of Engineers between 1928 and 1930. Built at a time when the Corps was still committed to open water navigation on the Upper Mississippi, the installation includes a 100-foot wide navigable pass adjacent to the lock. The dam was also built with 20 Tainter gates, and acted as an "engineering link" between the 6-foot channel and the 9-foot channel system.

Note: Gate dimensions are approximate figures based on the general notations found in U.S. Army Corps of Engineers' publications. For example, roller gates are often shown as a standard 80 by 20 feet. However, in the more detailed construction history notations, gate sizes are often given exactly as 88 feet, 10 1/2-inches long and 15 feet in diameter. Similar approximations apply to Tainter gates. In both instances, the dimensions should be taken only as approximations for use in categorizing gate sizes and styles, and not as exact measurements.



(Above) Similar to all the construction drawings for the 9-Foot Channel Project dams, the plan for Dam No. 3 shows the arrangement of dam gates, as well as sectional views of the gates and piers. Dam No. 3 General Plan, September 1936. (U.S. Army Corps of Engineers, St. Paul District)

(Below) Roller Gates, Dam No. 3. (Clayton B. Fraser, Fraserdesign)



Lock and Dam No. 3

Date of Construction: 1935-1940

Location: Six miles upstream from Red Wing, Minnesota

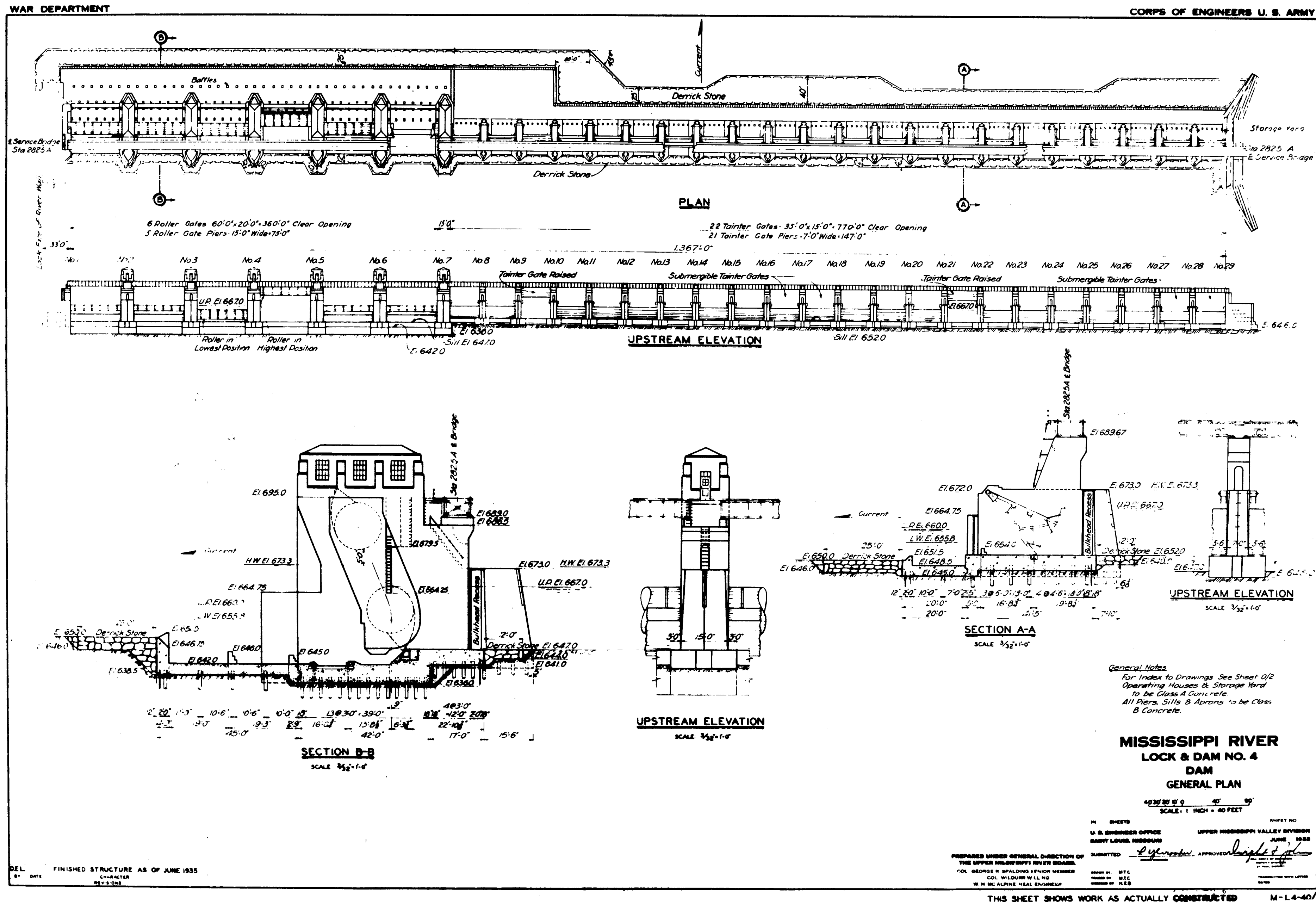
General Setting: The complex is on the Minnesota side of the river. The old river channel at this point normally measured about 600 feet; floodwaters increased the width to 2 1/2 miles at times.

Dam: The movable dam is 365 feet long, and consists of 4 submersible roller gates, 20 feet high and 80 feet long. The gates submerge to a depth of 5 feet. Each gate has its own independent hoist machinery. The gates and operating machinery were constructed and delivered to the site by the Lakeside Bridge and Steel Company of Milwaukee, Wisconsin. The dam foundations are set in sand.

Lock: Standard 110 by 600 feet, with additional gate and footings for an auxiliary lock. Upper normal pool elevation is 675 feet; lower pool elevation is 667 feet. Depth on upper miter sill is 17 feet; lower miter sill is 14 feet. Lock lift is 8 feet. The lock foundations are set in sand, silt, and clay.

History/Significance: Specific items of engineering significance include the exclusive use of submersible roller gates in the movable dam; the use of "Z" sheet piling in the abutment walls; and the replacement of all dam substrata. Prior to the construction of the dam, the Corps replaced approximately 200,000 cubic yards of unstable substrata with 130,000 cubic yards of river sand in order to provide a more stable foundation for the dam structure. The lock and dam elements of the complex were completed at a cost of $3,730,000. Fifty-three injuries took place during construction; no fatalities occurred.

General Contractors:
Lock: Spencer, White & Prentis, Inc., New York, New York
Dam: A. Gutherie Co., St. Paul, Minnesota
Hallett Construction Co., Crosby, Minnesota[8]



General Plan for Dam No. 4, June 1933. (U.S. Army Corps of Engineers, St. Paul District)

Lock and Dam No. 4

Date of Construction: 1932-1938

Location: Alma, Wisconsin

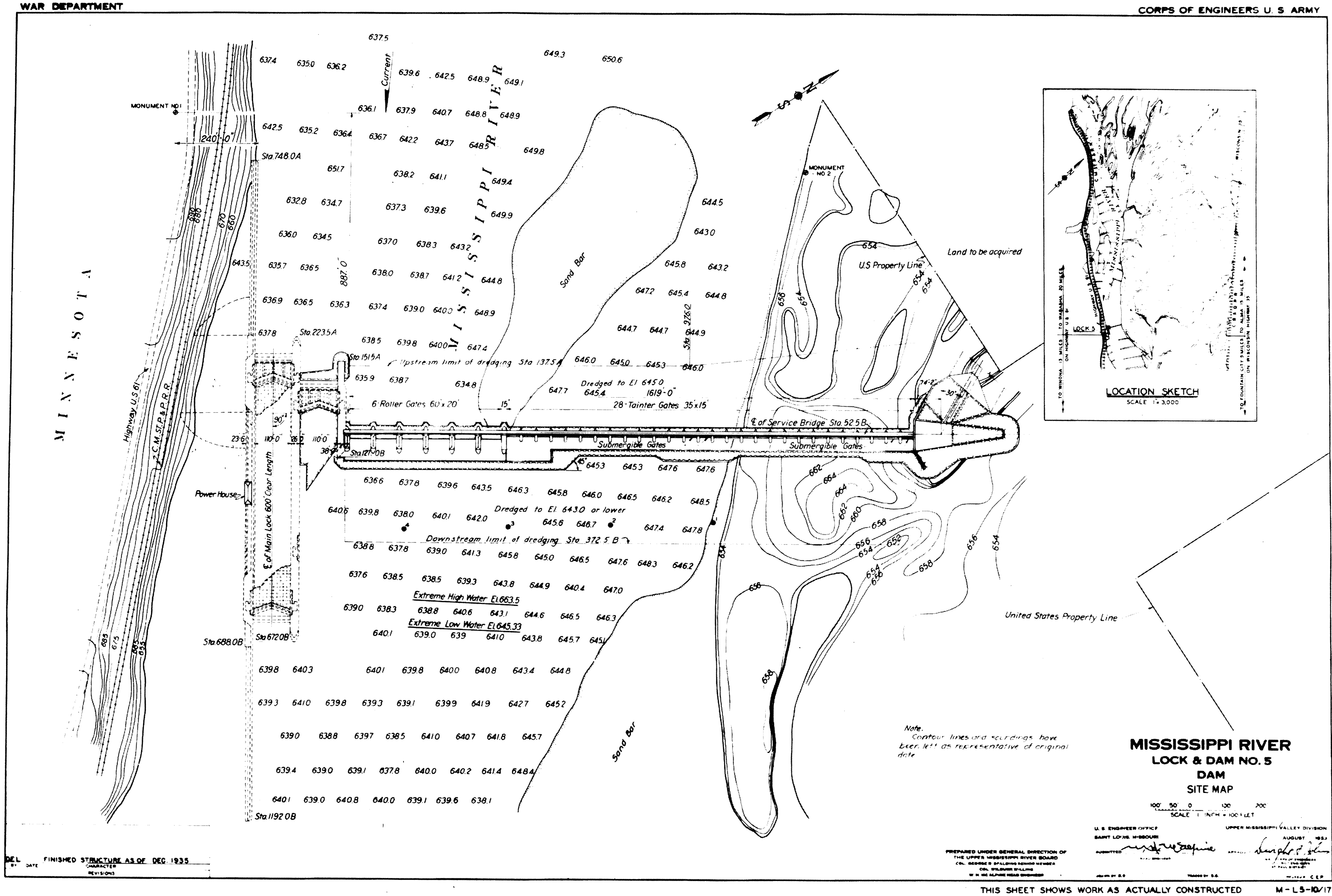
General Setting: Lock and Dam No. 4 is located about 90 miles below Minneapolis. The river bank was about 800 feet wide at the time of construction; high water increased this width by approximately 2,000 feet.

Dam: The movable dam consists of 6 submersible roller gates and 22 Tainter gates. Each roller gate is 20 feet high and 60 feet long, and is submersible for 3 feet. The roller gates--designed and built by the Treadwell Construction Co. of Midland, Pennsylvania, and installed by the McClintic-Marshall Corp. of Chicago--are all equipped with individual operating machinery. The Tainter gates, constructed and installed by the McClintic-Marshall Corp., are 15 feet high and 35 feet long. Tainter gates nos. 16, 17, 27, and 28 submerge 3 feet; the rest of the Tainter gates are non-submersible. The Tainter gates are controlled by a gasoline hoist that moves to each gate by means of a rail system on top of the bridge. The dam foundation consists of piles in sand and gravel.

Lock: Lock dimensions are the standard 110 by 600 feet. Lock lift is 7 feet. Upper normal pool elevation is 667 feet. Depth on upper miter sill is 17 feet; lower miter sill is 13 feet. The foundation is piles in sand and gravel.

History/Significance: At the time it was built, this dam's combination of roller and Tainter gates was believed to have been the first of its type to be constructed. Cold weather created several problems during construction of the complex. Approximately 120 timber pilings split and had to be pulled and replaced; engineers speculated that sap freezing in the green pilings may have caused the splitting. Ten major injuries, 296 minor injuries, and 3 deaths were reported during the construction of the dam.

General Contractors:
Lock: Ouillmette Construction and Engineering Co., Chicago, Illinois
Dam: United Construction Co., Winona, Minnesota[9]



Site Map for Dam No. 5, August 1933. (U.S. Army Corps of Engineers, St. Paul District)

Lock and Dam No. 5

Date of Construction: 1933-1939

Location: Near Minneiska, Minnesota; 5.5 miles upstream of Fountain City, Wisconsin

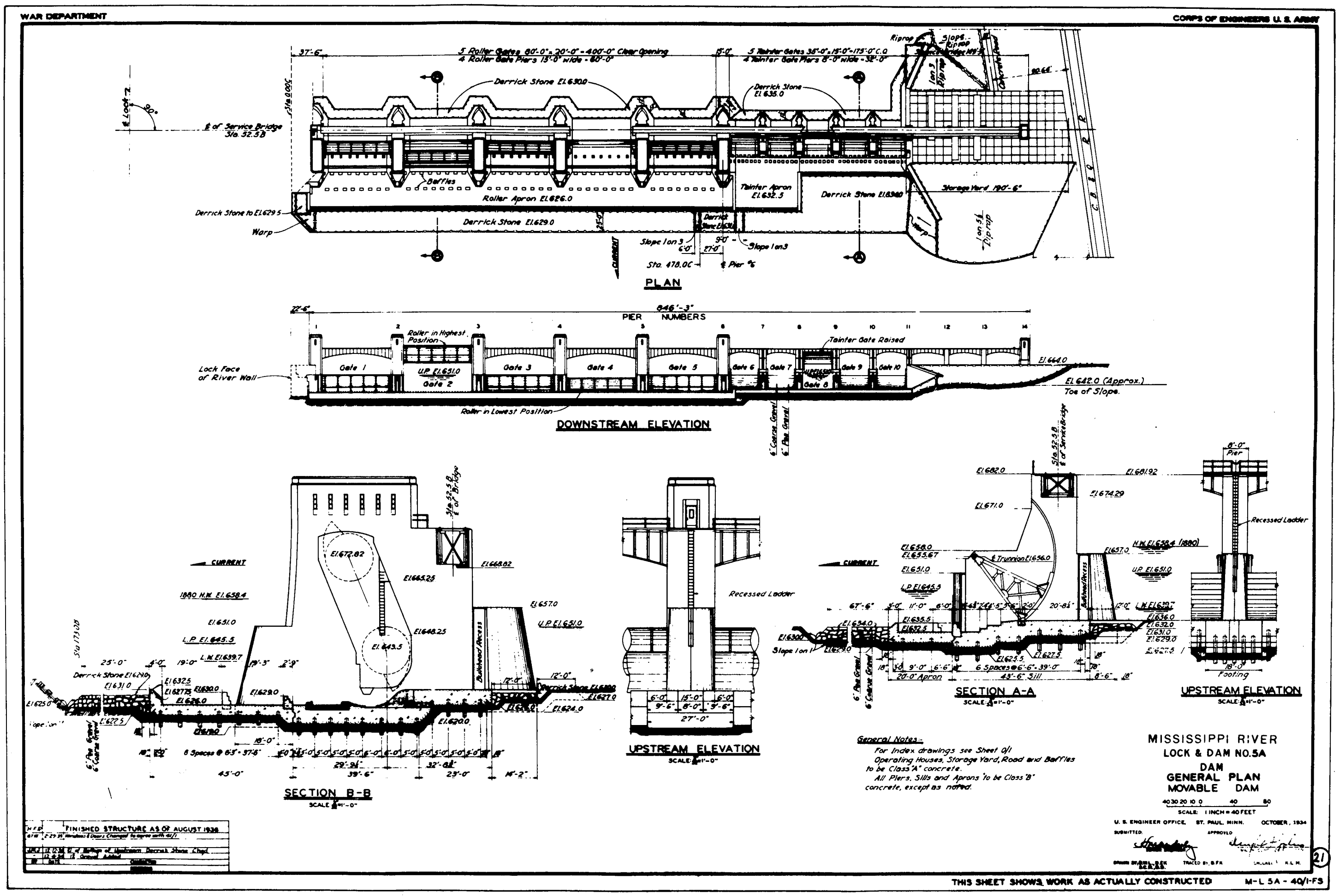
General Setting: Lock and Dam No. 5 is 114.75 miles downstream from Minneapolis. The river was, at the time of construction, about 2 to 2 1/2 miles wide with the main channel at the foot of the bluff. The river normally maintained a width of 800 feet, widening to 2 miles in flood stages.

Dam: The 1,619-foot-long movable dam is composed of 24 non-submersible Tainter gates, 15 feet high and 35 feet long; 4 submersible Tainter gates of the same dimensions; and 6 submersible roller gates, 20 feet high and 60 feet long. Both the submersible Tainter gates and the roller gates submerge to a depth of 3 feet. All of the gates are located between concrete piers topped with a steel service deck. The dam foundation is set on piles in sand.

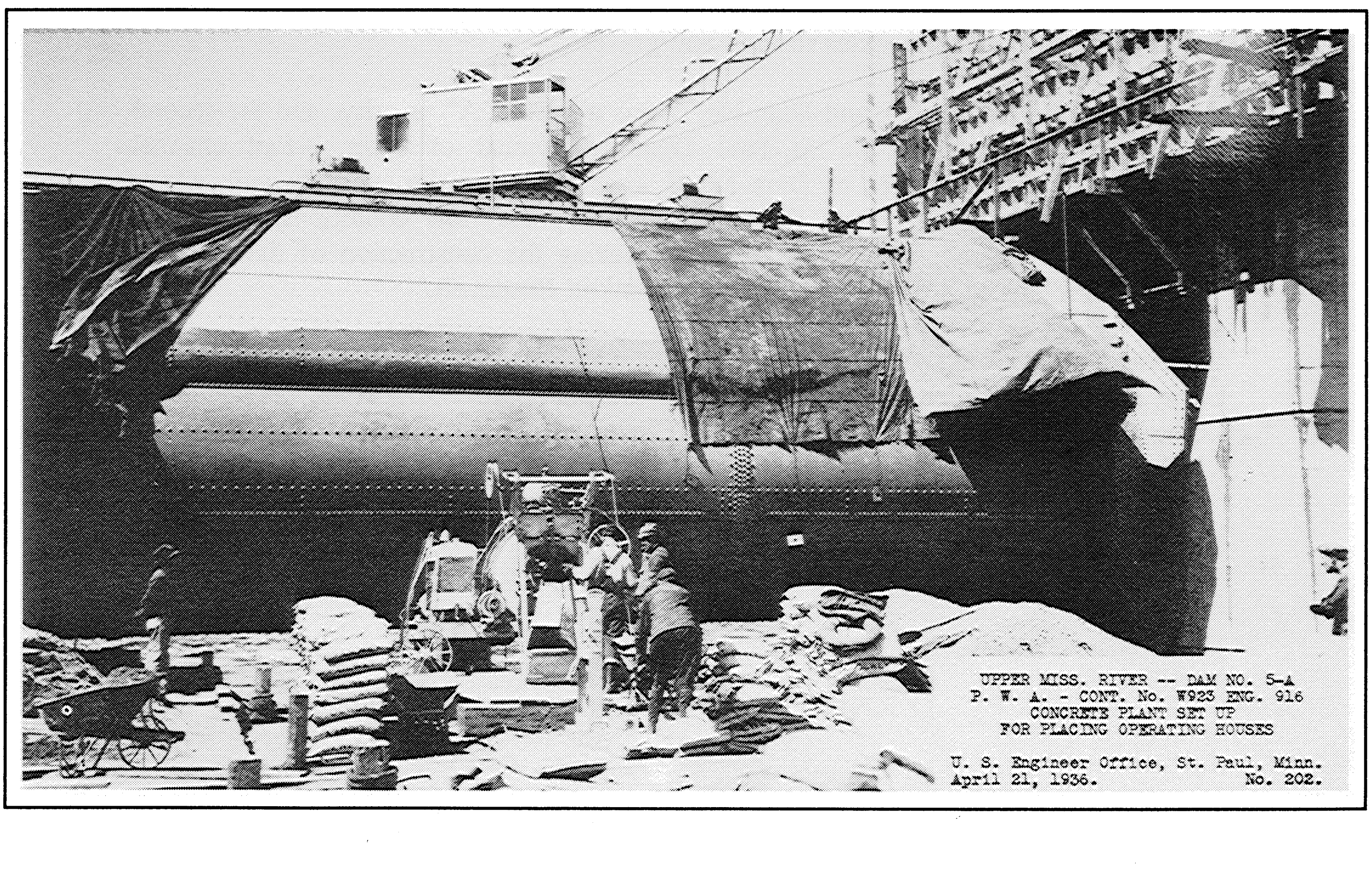
Lock: Standard 110 by 600 feet, with the upper gate of an auxiliary lock located in the main channel next to the Minnesota shoreline. Lock lift is 9 feet. Upper normal pool elevation is 660 feet. Depth on upper miter sill is 18 feet; lower miter sill is 12 feet. The foundation consists of piles in sand and gravel.

History/Significance: Lock and Dam No. 5 was a group "A" priority, and the second installation completed in the St. Paul District. Typical of other 9-foot channel installations, the roller gates on Dam No. 5 were located in the main channel, where they could handle the greatest flooding and heavy ice flow conditions. One fatal accident, involving a private craft, occurred during the construction of the dam. In 1934, the site hosted a presidential visit by Franklin Roosevelt.

General Contractors:
Lock: Edward E. Gillen Co., Milwaukee, Wisconsin
Dam: Merritt-Chapman & Whitney Corp., Cleveland, Ohio[10]



(Above) General Plan for Lock and Dam No. 5A, October 1934. (U.S. Army Corps of Engineers, St. Paul District)
(Below) Workers setting up concrete plant at Dam No. 5A, April 1936. (U.S. Army Corps of Engineers, St. Paul District)



Lock and Dam No. 5A

Date of Construction: 1934-1938

Location: Three miles above Winona, Minnesota

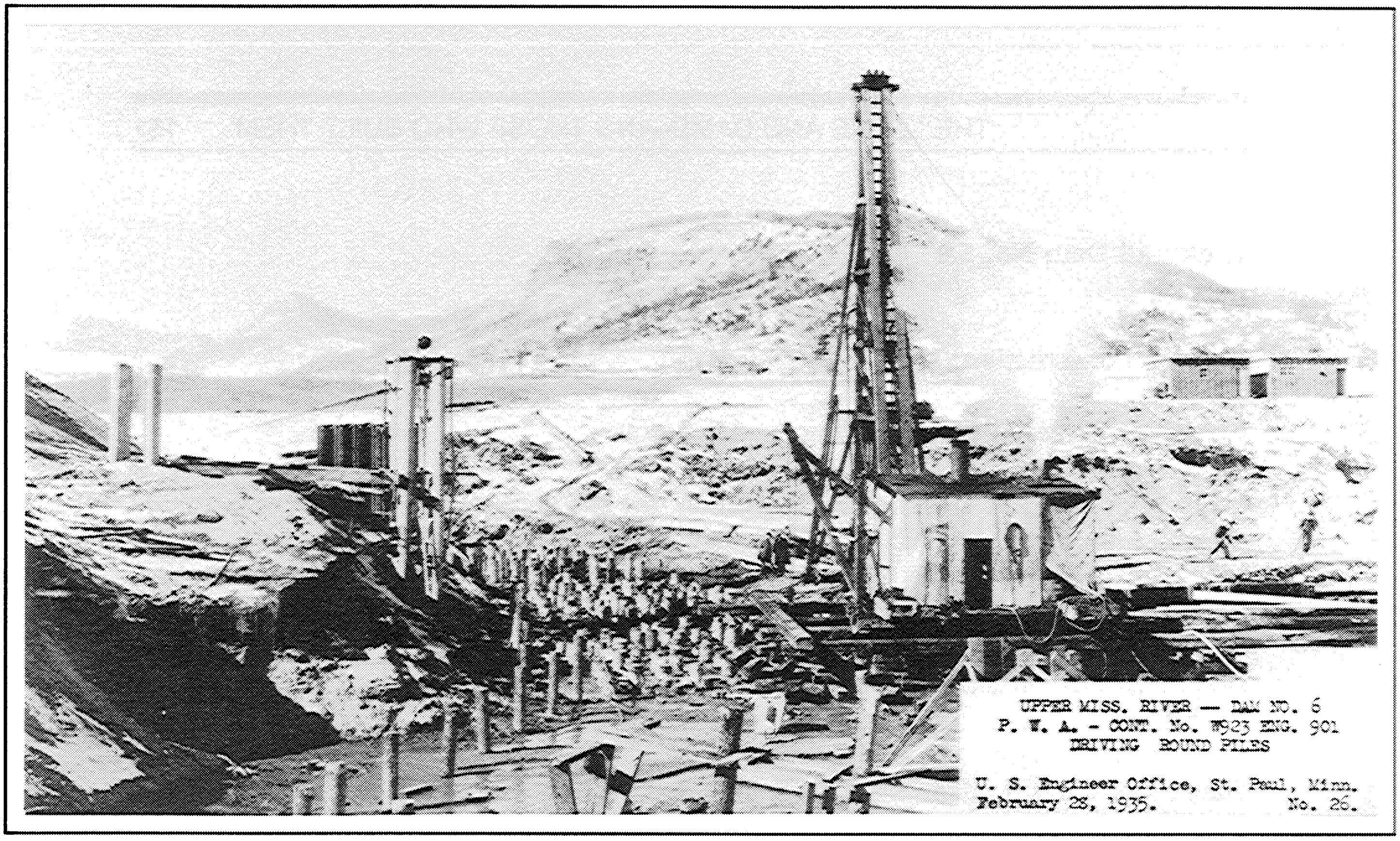
General Setting: At the time of construction, the site consisted of low, swampy ground separated by three sloughs: Blackbird Slough, Straight Slough, and Crooked Slough. Many small lakes were in the area, interrupted by sections of relatively high ground. The lock and dam site, located in the middle of the river channel, incorporated a number of islands into its earth dike system. The location of the complex in a slough on the left side of Islands 67 and 68 allowed for the main channel to serve an exclusive spillway function.

Dam: The movable dam is 682 feet long and consists of 5 submersible roller gates, 20 feet high and 80 feet long; and 5 non-submersible Tainter gates, 15 feet high and 35 feet long. The roller gates submerge 3 feet. A 1,000-foot overflow spillway, 5,344-foot earth dike, and connecting stub dike were also completed as part of the dam system.

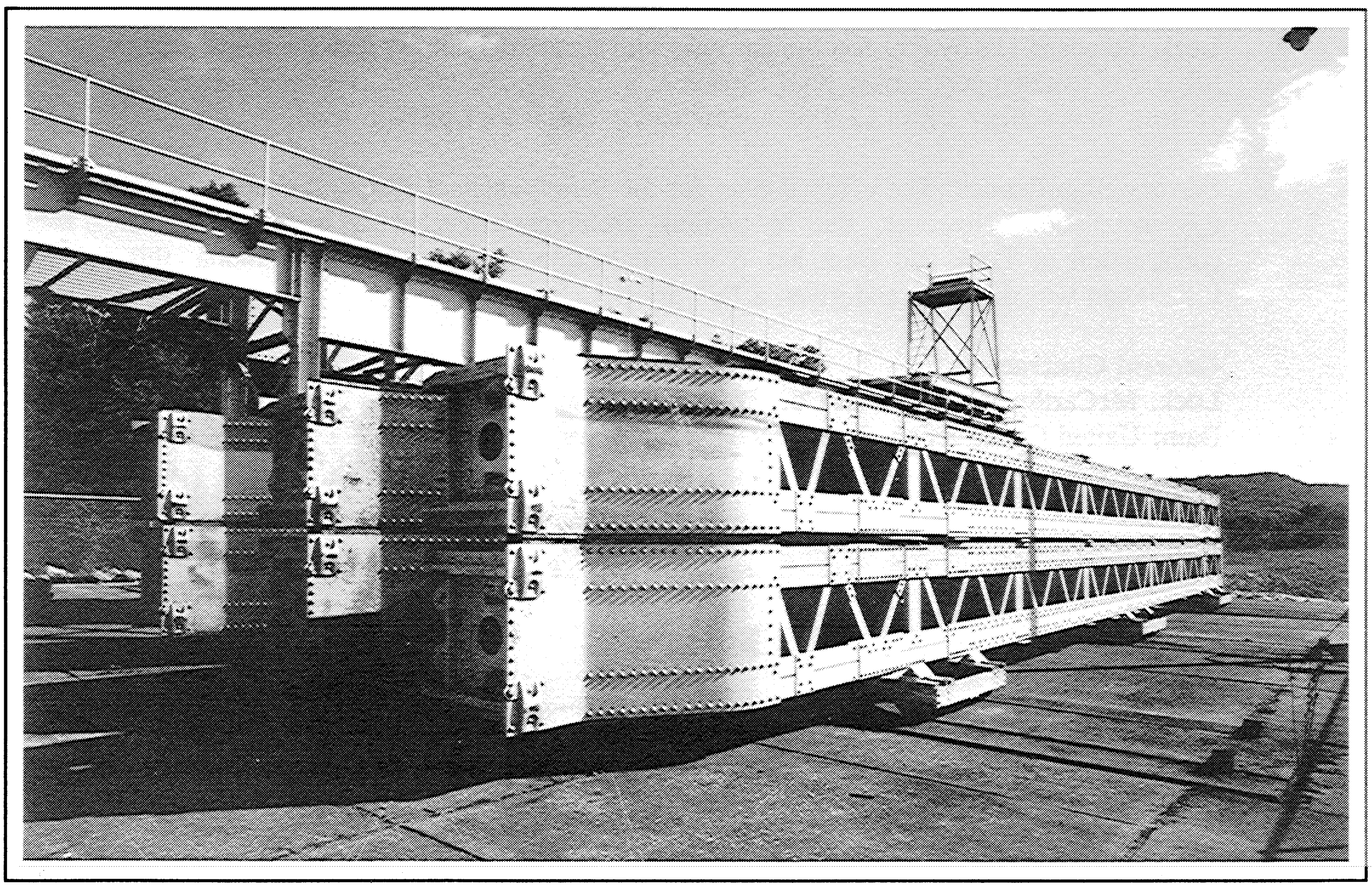
Lock: Standard 110 by 600 feet dimensions, with standard auxiliary lock elements. Lock lift is 5.5 feet. Upper normal pool elevation is 651 feet. Depth on upper miter sill is 18 feet; lower miter sill is 12.5 feet. Foundation consists of piles in sand.

History/Significance: The original plan for the 9-foot channel system did not include this installation. However, due to pooling problems projected as a result of the construction of Lock and Dam No. 6 in conjunction with the City of Winona, this installation was designed and given a "B" priority.

General Contractors:
Lock: McCarthy Improvement Co., Davenport, Iowa
Dam: United Construction Co., Winona, Minnesota[11]



(Above) Driving Piles at Dam No 6, February 1935. (U.S. Army Corps of Engineers, St. Paul District)
(Below) Roller Gate Bulkheads, Dam No. 6. The individual gate bays on the dam can be closed off with bulkheads and then drained for repairs. (Clayton B. Fraser, Fraserdesign)



Lock and Dam No. 6

Date of Construction: 1933-1938

Location: Trempealeau, Wisconsin

General Setting: The complex is 139 miles below Minneapolis. The normal river stage was 1/4-mile wide, with a high water width of approximately 2,000 feet. Steep sandstone bluffs bordered the mile-wide valley. The area was a popular summer home location.

Dam: The movable dam is 893 feet long and consists of 5 submersible roller gates, 20 feet high and 80 feet long; and 10 non-submersible Tainter gates, 15 feet high and 35 feet long. The roller gates submerge 3 feet, and were constructed and erected by the American Bridge Co. of Gary, Indiana--in conjunction with the S. Morgan Smith Co. of York, Pennsylvania; Cutler-Hammer, Inc.; Century Electric; and Foot Brothers. The Tainter gates were constructed and erected by the American Bridge Co. Dam foundations are piles in sand and clay.

Lock: Standard 110 by 600 feet dimensions, with standard auxiliary lock elements. Upper normal pool elevation is 645.5 feet. Depth of upper miter sill is 17 feet; lower miter sill is 12.5 feet. Lock lift is 6.5 feet. The lock foundation consists of piles in sand and gravel.

History/Significance: The Tainter gates in Dam No. 6 were the first in the St. Paul District to employ independent operating machinery instead of hoist car systems. During construction, the frozen river was sometimes used as a work base, as the ice was often 12 to 18 inches thick. Piles were dragged over the ice by teams of draft animals. The construction of Lock and Dam No. 6 also resulted in innovations in pile driving. Timber pilings--elm, maple, hickory, ash, oak, yellow birch, and pine--were driven by new, skid-type, pile drivers built on the job site by a contractor. A new method of keeping the pile drivers level was also developed by the contractor.

General Contractors:
Lock and Dam: Spencer, White & Prentis, Inc., New York, New York[12]

(Above) Roller Gate, Dam No. 7. (Clayton B. Fraser, Fraserdesign)
(Below) Like many of the 9-foot channel installations, the Lock and Dam No. 7 site includes a fixed submersible dam and earth dike. (Clayton B. Fraser, Fraserdesign)

Lock and Dam No. 7

Date of Construction: 1933-1940

Location: Dresbach, Minnesota; near Onalaska, Wisconsin

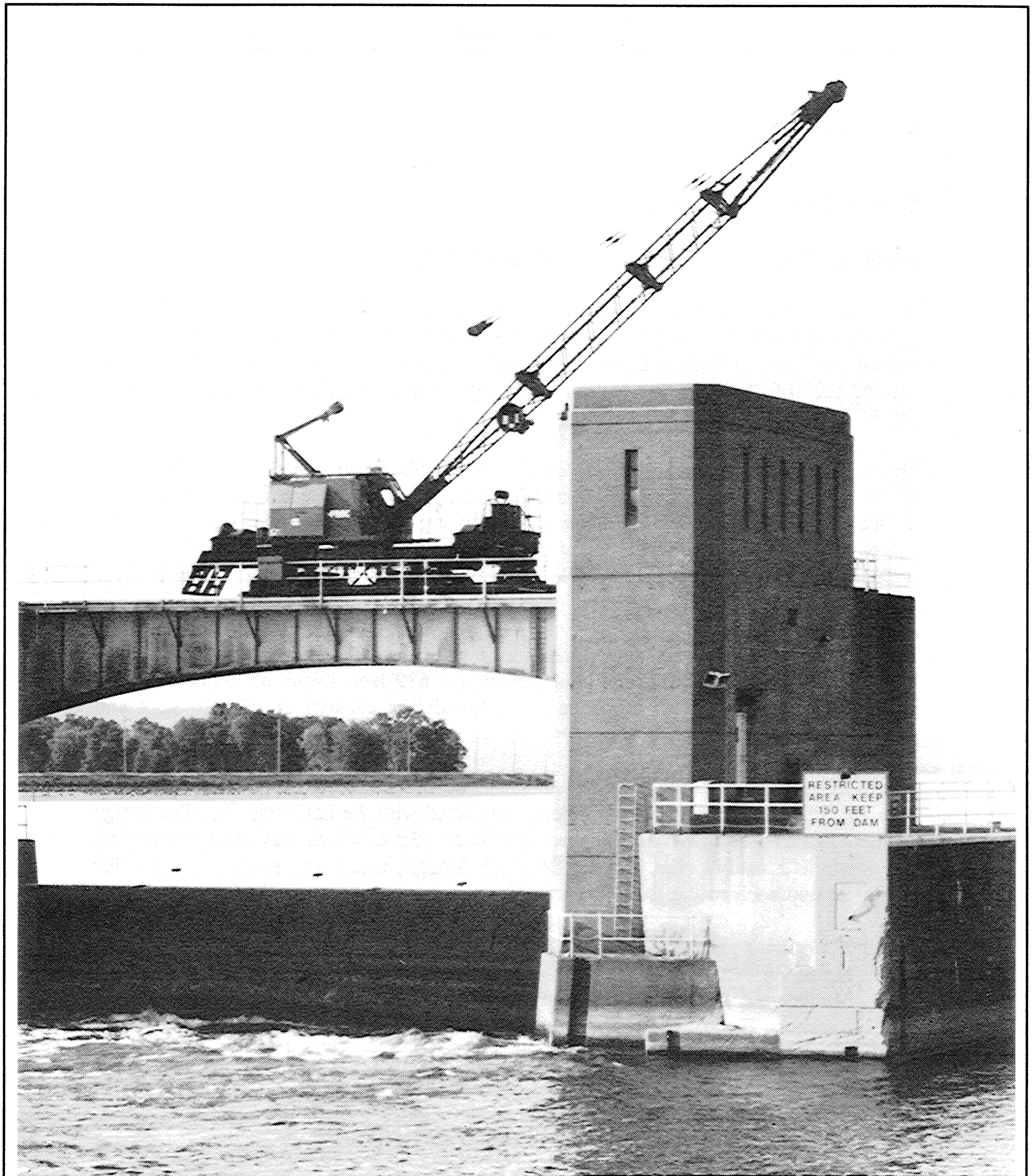
General Setting: The site is 4.5 miles above LaCrosse, Wisconsin, and approximately 150.7 miles below Minneapolis. Normal river width was approximately 1,000 feet; the terrain consisted of bottom lands interrupted by sections of high land. French Island, located 8,000 feet east of the eastern bank, separates the Black River from the rest of the Mississippi Valley.

Dam: The 940-foot movable dam has 5 submersible roller gates, 20 feet high and 80 feet long; and 9 non-submersible and 2 submersible Tainter gates, 20 feet high and 35 feet long. The submersible Tainter gates submerge 2 feet; the roller gates submerge 3 feet. The gates were fabricated by the Bethlehem Steel Co. The dam system also includes a fixed, 670-foot submersible dam, and a 9,003-foot earth dike. Foundations are piles in sand.

Lock: Standard 110 by 600 foot dimensions, with an auxiliary lock 110 by 360 feet. Lock lift is 8 feet. Upper normal pool elevation is 639 feet. Depth on upper miter sill is 18 feet; lower miter sill is 12 feet. The foundation consists of piles in sand and gravel.

History/Significance: Originally scheduled to be nearer LaCrosse, this complex was relocated because of water level problems connected with the LaCrosse site. The design of the complex was heavily influenced by French Island, which was incorporated into the design as a natural dike, and the Dresbach Slough, which was reopened to provide the upper approach to the lock. The complex was built at a cost of $6,776,000.

General Contractors:
Lock: Nolan Brothers, Minneapolis, Minnesota;
Minneapolis Dredging Co., Minneapolis;
Dearborn Electrical Construction Co., Chicago, Illinois
Dam: Warner Construction Co., Chicago, Illinois[13]



Movable Crane on Dam No. 8 Bridge. (Clayton B. Fraser, Fraserdesign)

Lock and Dam No. 8

Date of Construction: 1933-1938

Location: Genoa, Wisconsin

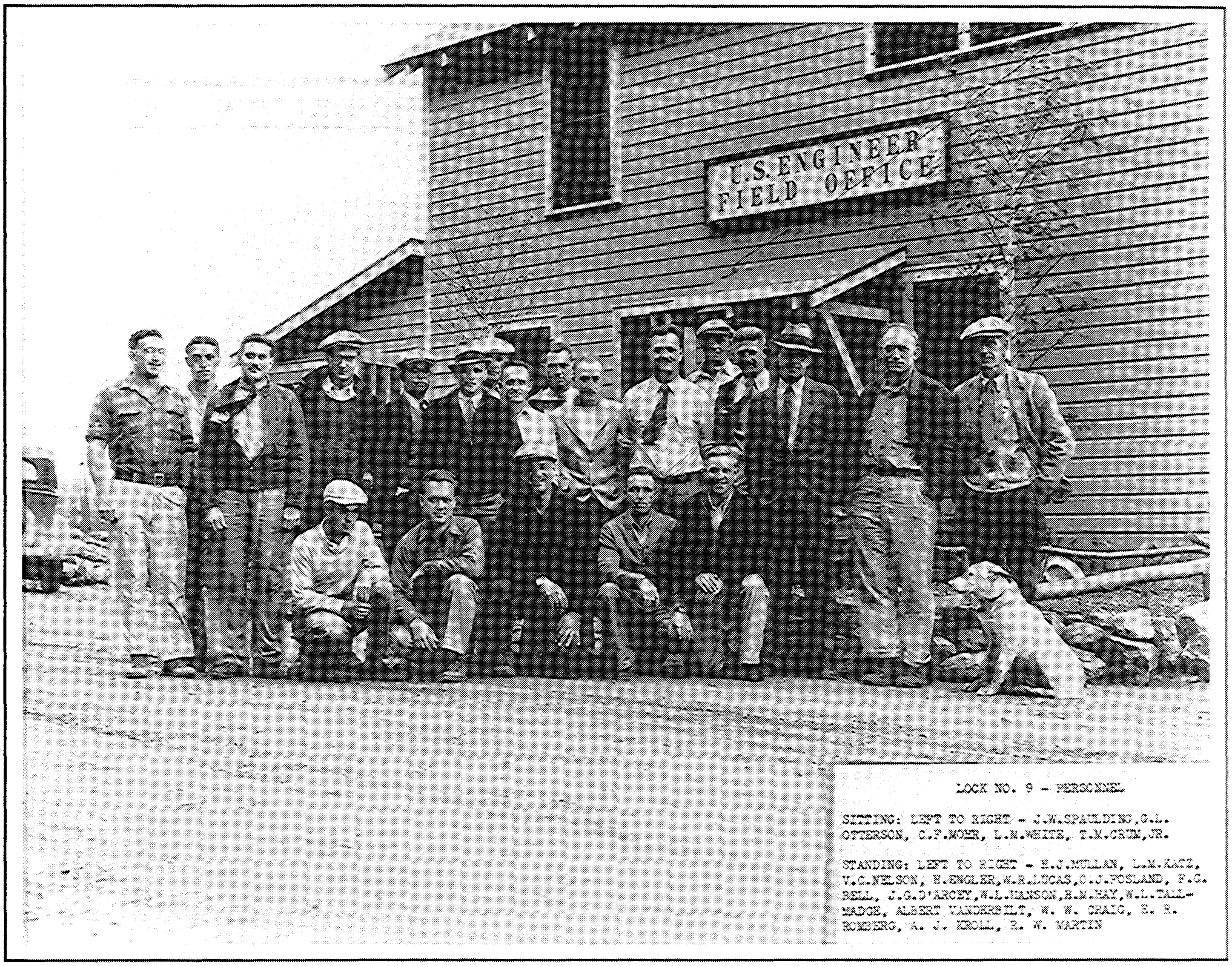
General Setting: The complex is 173.4 miles below Minneapolis. At the time of construction, the river at this location was approximately 1,200 feet wide at normal stages, increasing to 13,000 feet at periods of high water. The terrain consisted of sand flats with brush and willows; timber was located on the higher ground.

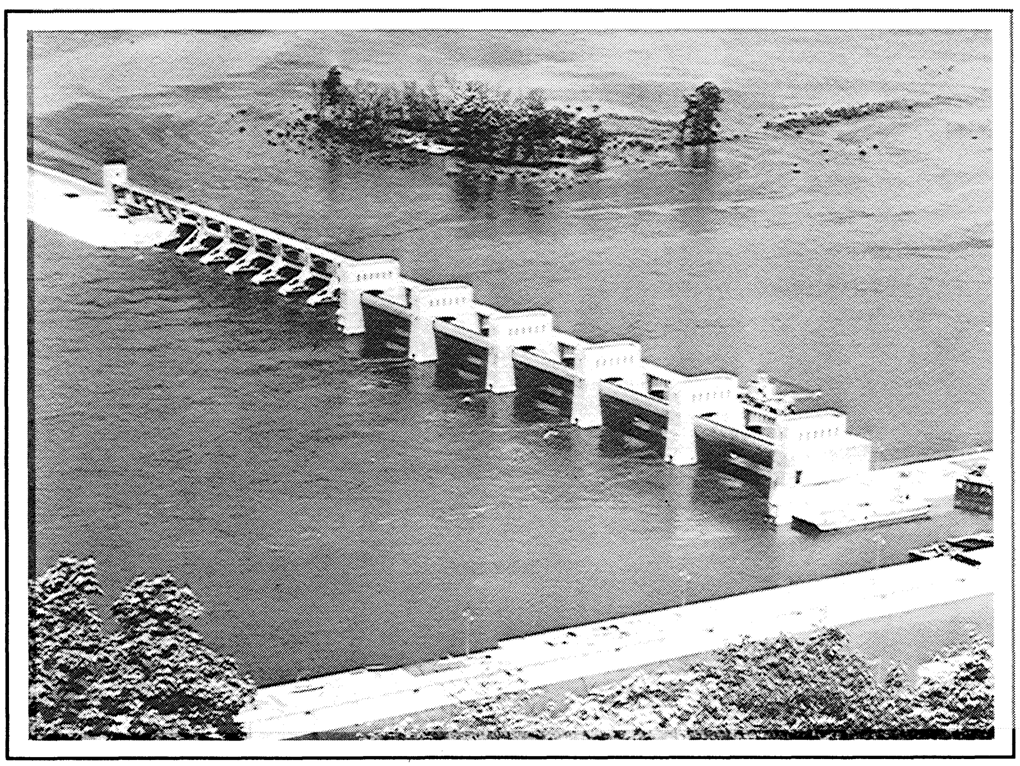
Dam: The movable dam is 934.5 feet long and consists of 5 submersible roller gates, 20 feet high and 80 feet long; and 8 non-submersible and 2 submersible Tainter gates, each 15 feet high and 35 feet long. The roller gates submerge to a depth of 3 feet; the submersible Tainter gates to a depth of 2 feet. Two submersible dams with lengths of 937.5 and 1,337.5 feet and an earth-filled dike with a total length of 15,720 feet are also included in the complex. The foundation consists of piles in sand and gravel.

Lock: Lock dimensions are the standard 110 by 600 feet, with a planned auxiliary lock 110 by 360 feet. Lock lift is 11 feet. Upper normal pool elevation is 631 feet. Depth on upper miter sill is 22 feet; lower miter sill is 14 feet. The foundation materials consist of piles in sand, gravel, and broken clay.

History/Significance: The design of Lock and Dam No. 8 was not dictated by unusual river hydrology so much as for the need for a lock and dam system at that point of the river so that the 9-foot channel system might function properly. The complex was completed at an estimated cost of $7,728,000. Eighty-six accidents and one fatality occurred during dam construction; no accidents or fatalities were reported during construction of the lock.

General Contractors:
Lock: Jutton-Kelly Company, Milwaukee, Wisconsin
Dam: Siems-Helmers, Inc., St. Paul, Minnesota[14]





(Above) Field Office Staff at Lock and Dam No. 9, c. 1936. (American Heritage Center, University of Wyoming)

(Left) Lock and Dam No. 9, May 1938. (U.S. Army Corps of Engineers, St. Paul District)

Lock and Dam No. 9

Date of Construction: 1936-1940

Location: Below Lynxville, Wisconsin

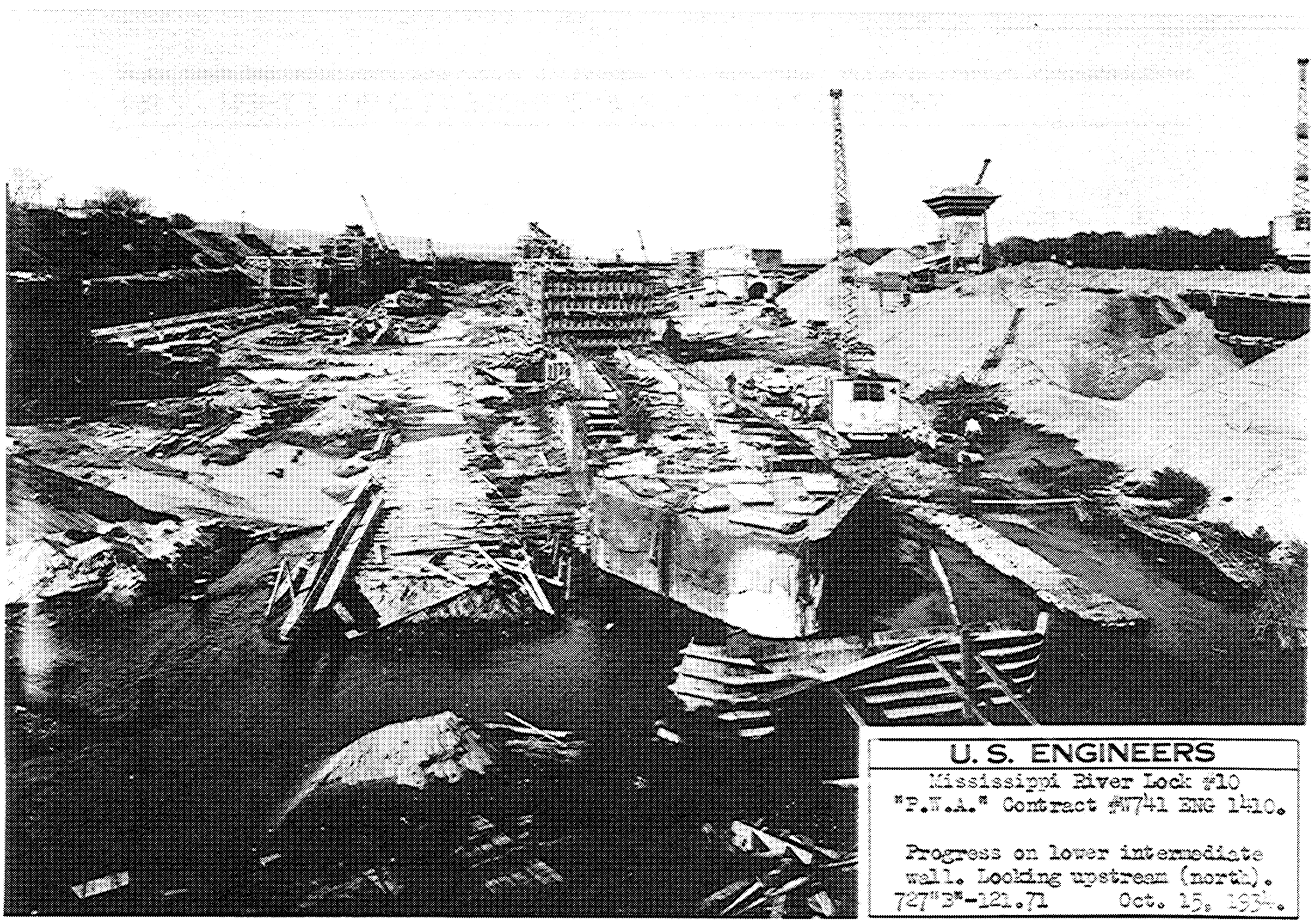
General Setting: Lock and Dam No. 9 is located 205.1 miles below Minneapolis. Prior to construction of the complex, the Mississippi River in this area was approximately 1,100 feet wide at normal levels, spreading to approximately 10,000 feet in flood stages.

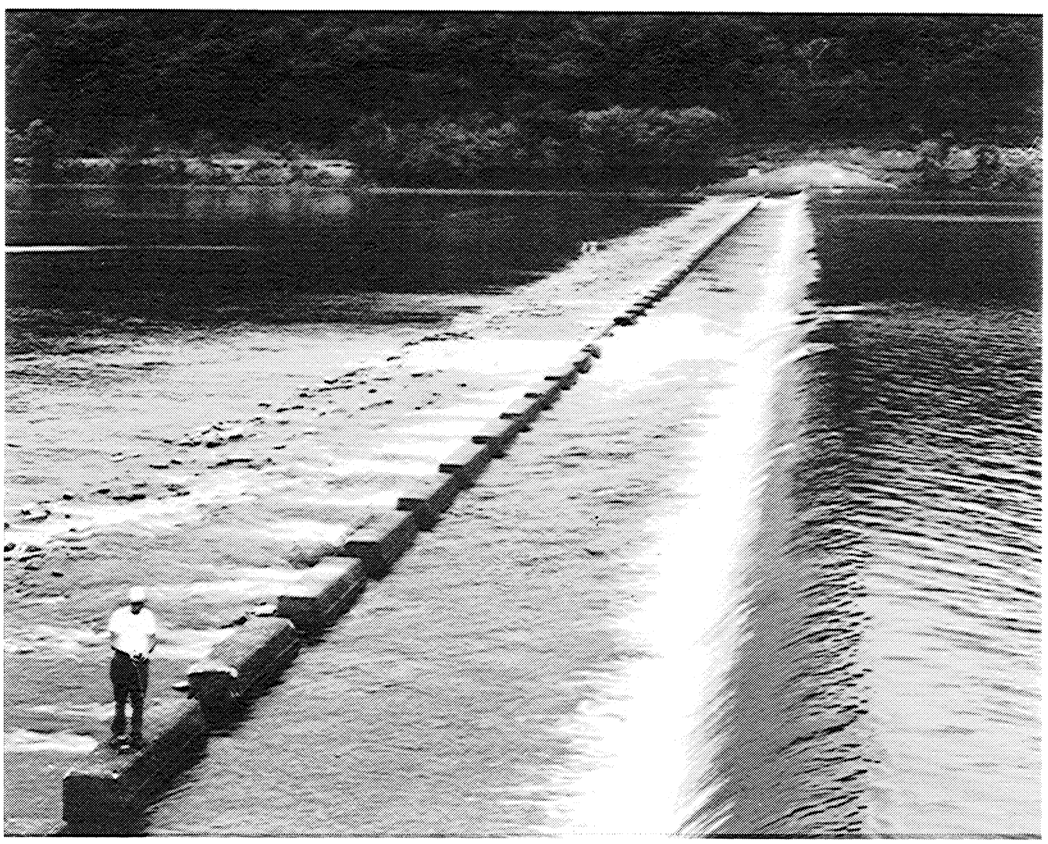
Dam: The movable dam is 811 feet long, and consists of 5 submersible roller gates, 20 feet high and 80 feet long; and 2 submersible and 6 non-submersible Tainter gates, 15 feet high and 35 feet long. The roller gates submerge to a depth of 5 feet. The submersible Tainter gates, which submerge 2 feet, are located adjacent to the abutment pier. An earth dike extends from the far Tainter gate abutment northwest for 8,004 feet, and is intersected by a submersible dam 1,350 feet long. The foundation is made up of piles in sand.

Lock: Standard configuration of 110 by 600 feet, with a planned auxiliary lock of 110 by 360 feet. Lock lift is 9 feet. Upper normal pool elevation is 620 feet. Depth on upper miter sill is 16 feet; lower miter sill is 13 feet. The foundation is set on piles in sand.

History/Significance: Due to a good 6-foot channel and relatively trouble-free engineering and environmental characteristics, Lock and Dam No. 9 was a group "B" priority, and the second-to-last complex built by the St. Paul District. The complex was completed at an estimated cost of $8,287,000.

General Contractors:
Lock: Walter W. Magee Co., St. Paul, Minnesota
Dam: United Construction Co., Winona, Minnesota[15]





(Above) Construction of Lock Wall, October 1934. (U.S. Army Corps of Engineers, St. Paul District)

(Left) Submersible Dike in Dam No. 10. (Clayton B. Fraser, Fraserdesign)

Lock and Dam No. 10

Date of Construction: 1934-1937

Location: Guttenberg, Iowa

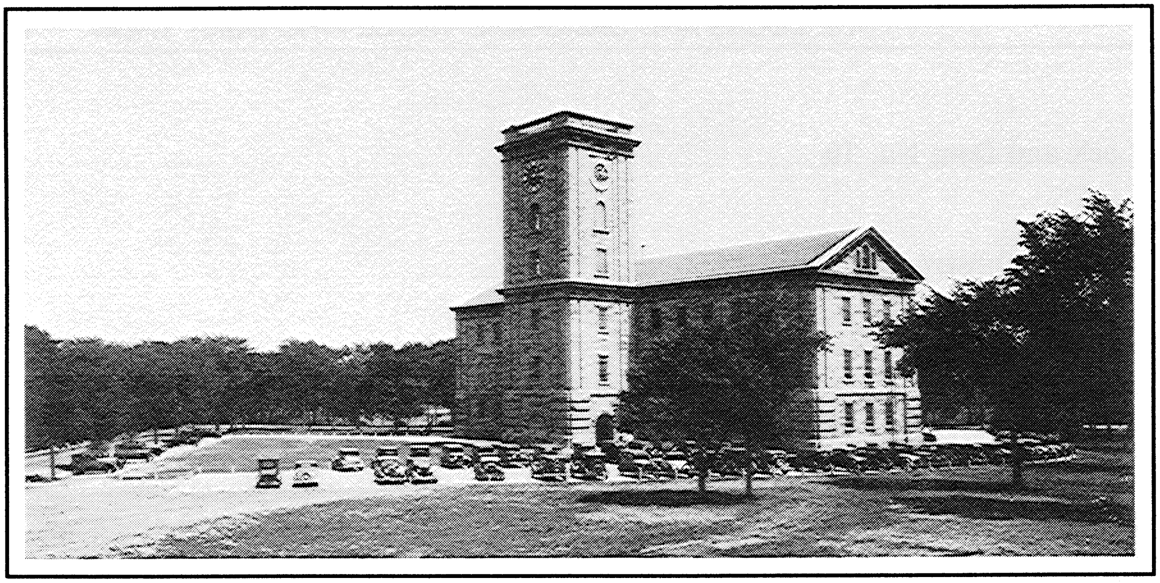
General Setting: Originally scheduled at Cassville, Wisconsin, the location of this complex was changed to Guttenberg because of flooding-related problems. The site is 16 miles below the mouth of the Wisconsin River, and 615.1 miles above Cairo, Illinois. At the time of construction, the river valley was approximately 2 miles wide and alluvial in nature, with a river bed level at about 590 feet above sea level. The town of Guttenberg is situated on a low ridge, the rest of the riverbank areas being overgrown with brush. The dam crosses Island 189.

Dam: The movable dam consists of 4 non-submersible roller gates, 20 feet high and 80 feet long; and 8 Tainter gates, 20 feet high and 40 feet long. Two Tainter gates are located at the west end of the dam, the other six are at the east end. Six of the Tainter gates are non-submersible. The Tainter gates on each end are submersible to a depth of 3 feet. All of the gates are equipped with independent operating machinery. The dam system also includes a 4,547-foot earth dike embankment, and a fixed ogee spillway that is 1,200 feet in length. The dam foundation is piles in sand.

Lock: Standard dimensions of 110 by 600 feet, with a planned auxiliary lock of 110 by 360 feet. Lock lift is 8 feet. Depth on upper miter sill is 15 feet; lower miter sill is 12 feet. The foundation is piles in sand.

History/Significance: Built under the supervision and direction of the Rock Island District, Lock and Dam No. 10 was transferred to the St. Paul District's jurisdiction on October 1, 1939. The complex was completed at an estimated cost of $6,647,000.

General Contractors:
Lock: Hanlon and Oakes, St. Paul, Minnesota
Dam: McCarthy Improvement Co., Davenport, Iowa[16]



Rock Island District Office of the U.S. Army Corps of Engineers, Clock Tower Building, June 1934. (U.S. Army Corps of Engineers, Rock Island District)

The Rock Island District

The Rock Island District supervised the construction of Locks and Dams Nos.: 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, and 22. With the exception of Lock No. 19, all of the Rock Island District structures were constructed as part of the original 9-Foot Channel Project. The Corps of Engineers brought Lock No. 19, which includes the Keokuk and Hamilton Water Power Company dam and power plant, into its mature, 9-foot channel configuration in 1957.

Major Charles L. Hall, the same engineer who had conducted the initial, unfavorable, feasibility study of the 9-Foot Channel Project, was District Engineer of the Rock Island District at the beginning of the project. Six months after the project was signed into effect, Major Glen E. Edgerton replaced Hall, who left to teach at West Point. Major Edgerton served as District Engineer of the Rock Island District from December 1930 until August 1933. Prior to his Rock Island District appointment, Edgerton was Chief Engineer of the Federal Power Commission and a member of the Isthmian Canal Commission during the construction of the Panama Canal. These experiences served him well in his task of transforming the Rock Island District into a modern organization capable of handling the complex 9-Foot Channel Project.[17]

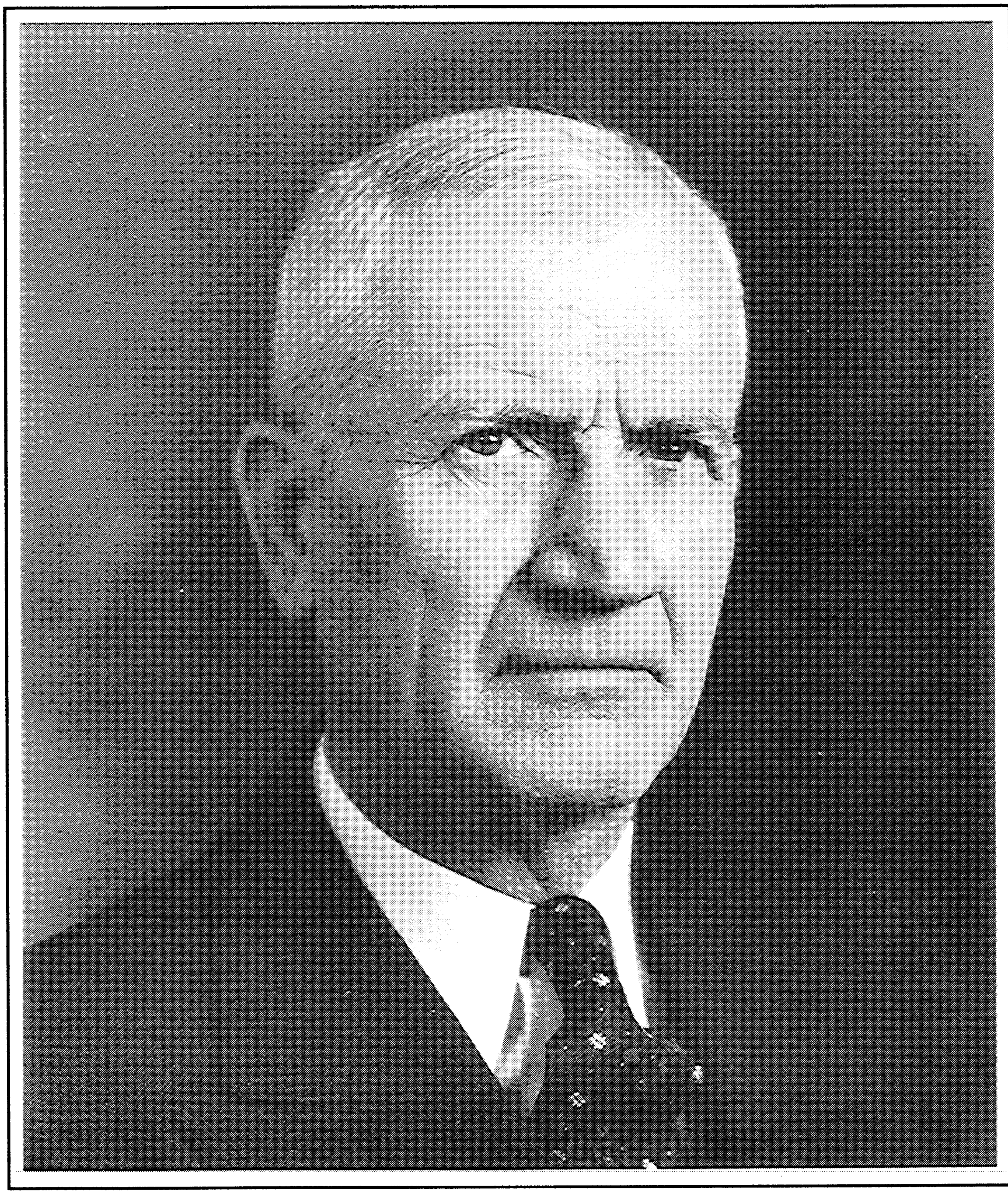
In order to build the 9-foot channel, the Rock Island District did not need a greatly expanded engineering staff. Since 1920, Richard A. Monroe had served as Principal Civilian Assistant to the District Engineer, providing technical leadership continuity in the Rock Island District. In November 1929, shortly after the UMVD was created, Monroe became the district's Senior Engineer.

While Monroe concentrated on the district's operational issues, Herbert G. McCormick did most of the actual engineering design work. McCormick had transferred into the Rock Island District in April 1930, after more than 20 years service with the Corps on the Ohio and Lower Mississippi Rivers. On the Ohio River project, McCormick was nationally recognized for his use of a plan to place concrete through chutes from a movable concrete mixer mounted on rails.[18]

Richard A. Monroe. (U.S. Army Corps of Engineers, Rock Island District)

In August 1933, Major Edgerton completed his 3-year tour of duty as Rock Island District Engineer. The 1933 decentralization of the 9-Foot Channel Project had made the job of District Engineer a much more important position, and Captain John M. Silkman served as Acting District Engineer until a suitably capable and illustrious officer became available to replace Edgerton. Major Raymond A. Wheeler, who graduated fifth in the West Point Class of 1911, was that up-and-coming officer. Wheeler, who later became

Chief of Engineers, served as District Engineer from September 1933 until October 1935, at which time he became Chief Regional Administrator of the Works Progress Administration (WPA). Major Earl E. Gesler replaced Wheeler.[19]

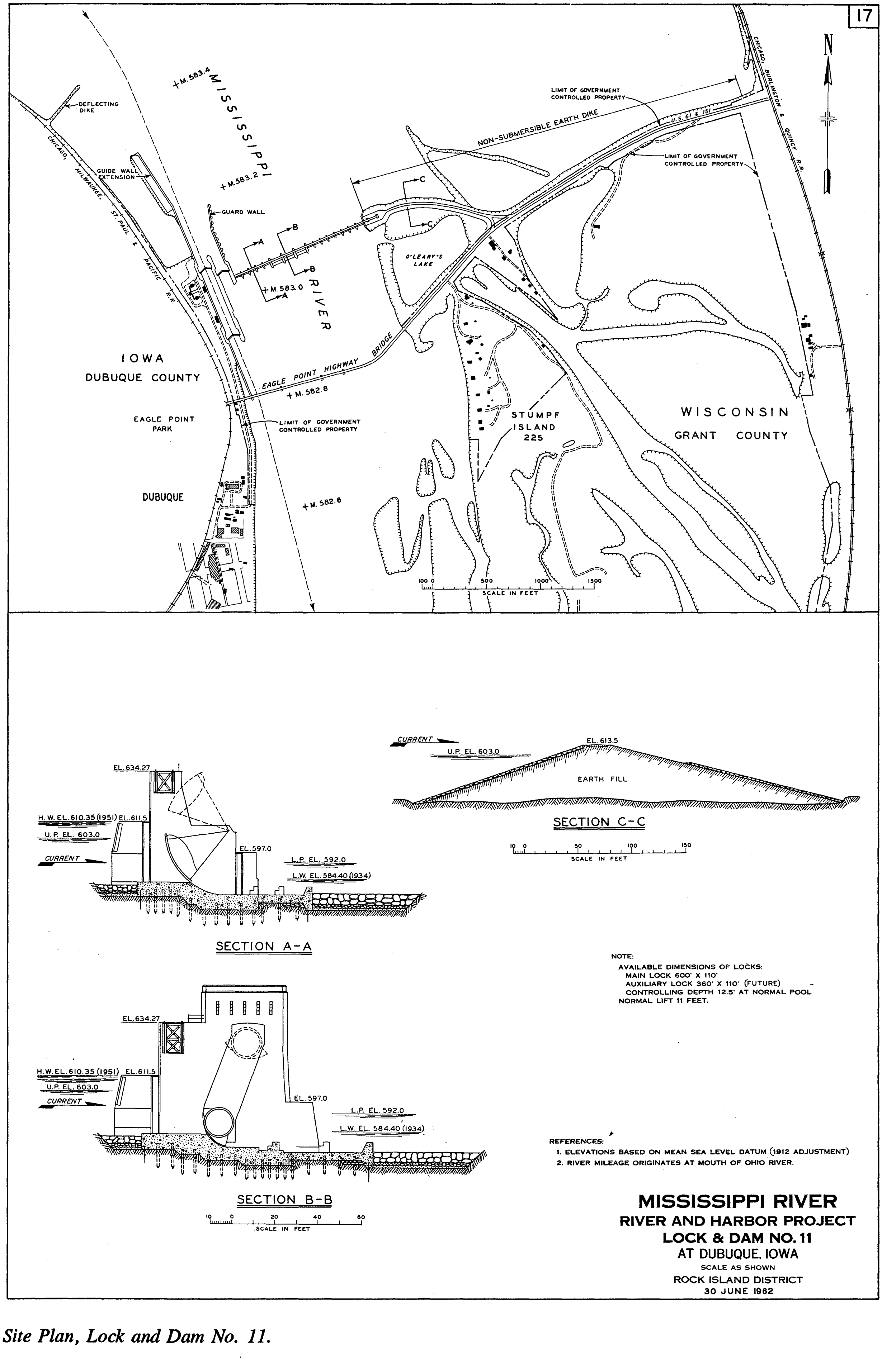


Herbert G. McCormick. (U.S. Army Corps of Engineers, Rock Island District)

The Rock Island District staff was also enlarged after the 1933 decentralization. Carelton E. Kelley transferred to Rock Island from the Chicago District office to become the first District Counsel and Chief of the Real Estate Division, a position he held until 1968. The district also enlarged its contract administration and construction supervision staffs. Within just a few months after the decentralization, the Rock Island District had to solicit and evaluate bids, select general contractors, and award six major project contracts. For contract purposes, each lock and each dam constituted a separate project, as did the power, control, and lighting of each lock and dam system. J.B. Alexander, the senior engineer in charge of the construction office, clearly had his hands full. In 1936, John Peil, who supervised the on-site construction of Lock and Dams No. 15 and 20, became head of the district's construction section. By the time Peil arrived in Rock Island, the district had 10 lock and dam complexes under simultaneous construction. Robert E. Clevenstine, who had also worked on site No. 20, followed Peil to the Rock Island District office, where he assumed responsibility for estimating and construction contract administration.[20]

The Rock Island District also reorganized and greatly enlarged its engineering staff after the decentralization. Monroe and McCormick remained with the district. However, after Lock and Dam No. 15 went on line in 1934, Monroe took over the primary responsibility for the operation of the facilities. Captain Silkman was in charge of the engineering division when the district assumed its new responsibilities in 1933. He was succeeded by Captain R.E. Coughlin and then Captain Henry Berbert.

Following the reorganization, Edwin E. Abbott transferred to the Rock Island District from the St. Louis UMVD design team. Taking over as chief civilian assistant, Abbott signed the contract drawings for the 10 locks, 11 dams, and 3 central control stations designed by the Rock Island District between 1933 and 1936. As early as the summer of 1933, Abbott had approximately 200 draftsmen assisting him in the production of these drawings. James Reeves and Edwin Franzen supervised the overall design of the dams, while Frank W. Ashton designed the dam gates.[21]



Site Plan, Lock and Dam No. 11.

Lock and Dam No. 11

Date of Construction: 1934-1937

Location: Dubuque, Iowa

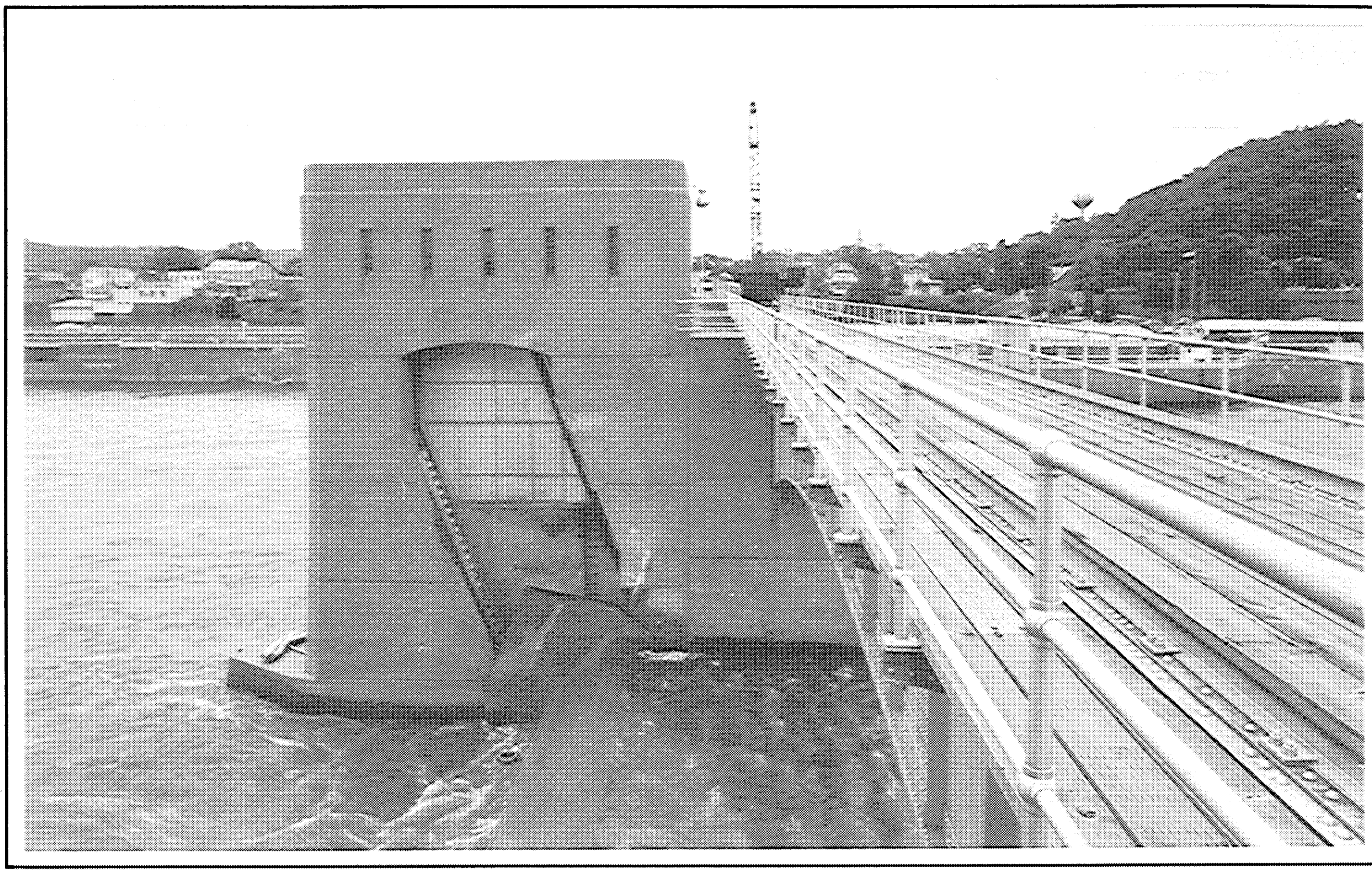
General Setting: The site borders on the northern edge of Dubuque, and is 583 miles above the confluence of the Ohio and Mississippi Rivers. Eagle Point Park occupies the high ground on the bluff above the lock and dam. A complex of islands and sloughs extends three-quarters of the way across the river from the Wisconsin shore. The Upper Mississippi River Wildlife and Fish Refuge occupies the land adjacent to the Wisconsin shore, both upstream and downstream from the dam.

Dam: The movable dam has 13 submersible Tainter gates, 20 feet high and 60 feet long; and 3 submersible roller gates, 20 feet high and 100 feet long. The roller gates submerge 8 feet. The dam system also includes a 3,540-foot long, curved, non-overflow, earth and sand-filled dike.

Lock: Lock dimensions are the standard 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 11 feet. Normal upper pool elevation is 603.0; approximately 19 feet above the tail waters below the dam at low water. When both pools are at their normal elevation, the difference is reduced to 11 feet or less.

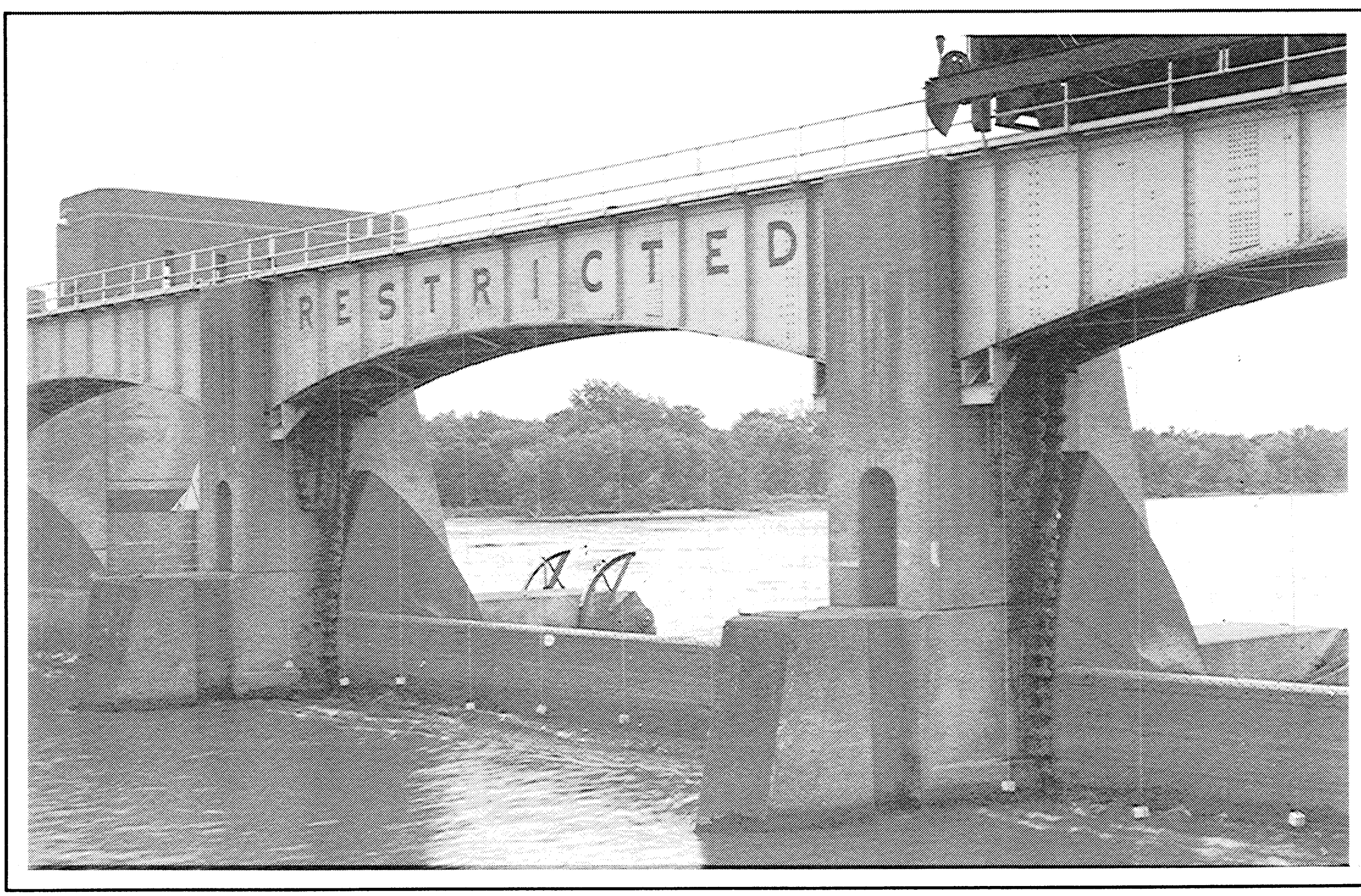
History/Significance: Lock and Dam No. 11 was scheduled to be above Sprecht's Ferry, Iowa, but in 1933 was relocated to Dubuque. The acute unemployment in Dubuque led the government to begin construction on this complex before many other group "C" projects in the Rock Island District. Dams Nos. 11 and 18 were designed concurrently, and were the first dams in the district to employ submersible, elliptical Tainter gates. They were also the first two dams in the district to use submersible roller gates. During the peak of construction, the complex, which cost $6,655,000, employed 901 people.

General Contractors:
Lock: Warner Construction Company, Chicago, Illinois
Dam: Maxon Construction Company, Inc., Dayton, Ohio[22]



(Above) Roller Gate, Dam No. 12. (Peter A. Rathbun)

(Below) Tainter Gate, Dam No. 12. (Peter A. Rathbun)



Lock and Dam No. 12

Date of Construction: 1934-1938

Location: Bellevue, Iowa

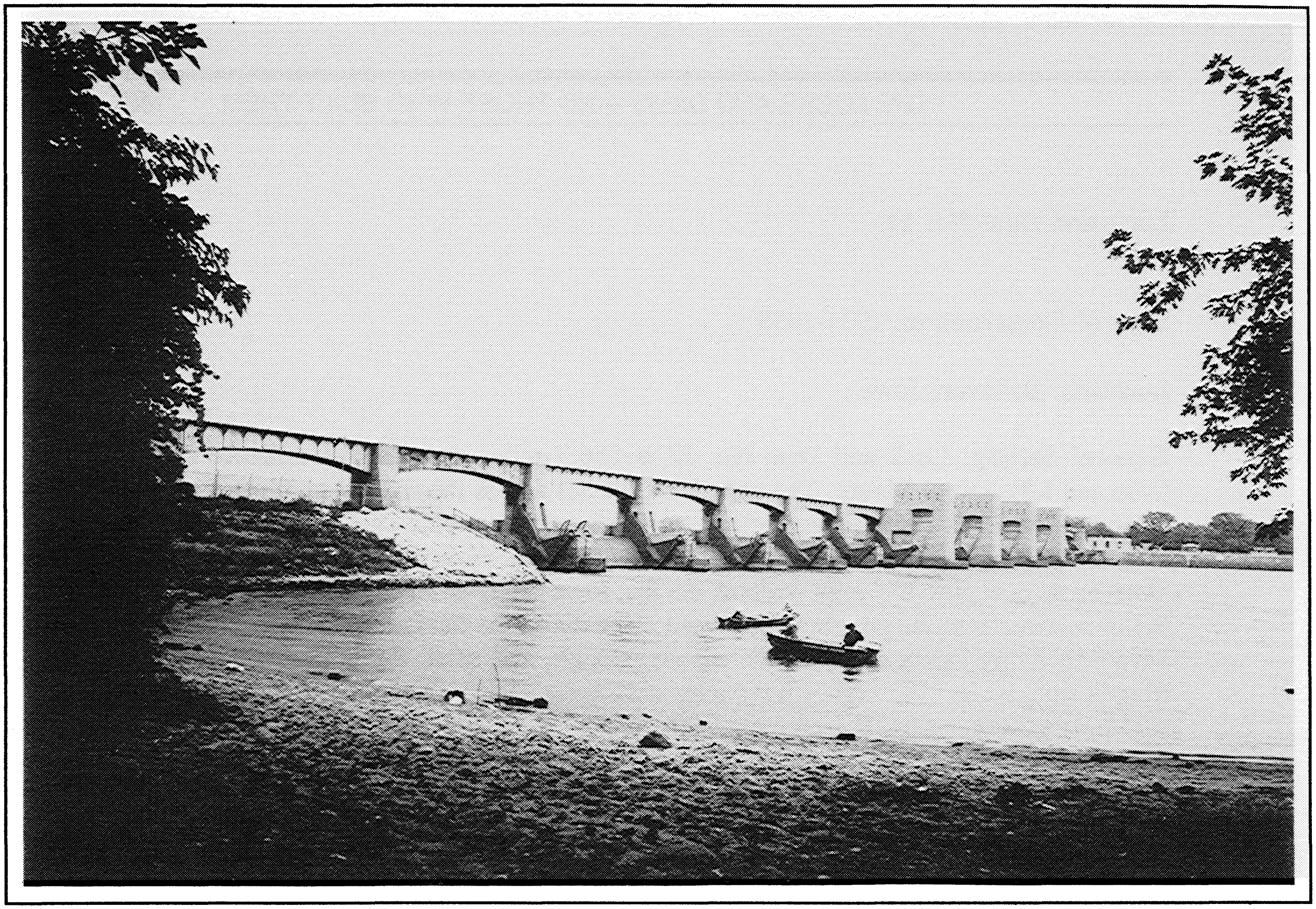
General Setting: Lock and Dam No. 12 is 556.7 miles above the confluence of the Ohio and Mississippi Rivers. The complex stretches across the river at a point where the bluffs on the Iowa side are very close to the river; a complex of islands and sloughs extends nearly three-quarters of the way across the river from the Illinois side. Bellevue State Park occupies the high ground on the Iowa side, while the urbanized area of Bellevue extends to the government-owned property on the flat land below the bluff. The Savannah Army Depot occupies the islands, slough, and small flat bottom areas on the Illinois side.

Dam: The movable dam consists of 7 submersible Tainter gates, 20 feet high and 64 feet long; and 3 submersible roller gates, 20 feet high and 100 feet long. The dam system also includes two, non-overflow, earth and sand-filled dikes; two transitional dikes; and a concrete-covered, ogee spillway, submersible earth and sand-filled dike. The foundation is set in sand, gravel, and silt.

Lock: Lock dimensions are the standard 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 9 feet. Normal upper pool elevation is 592 feet, approximately 15 feet above the tail waters below the dam at low water. When both pools are at their normal elevation, the difference is reduced to 9 feet or less.

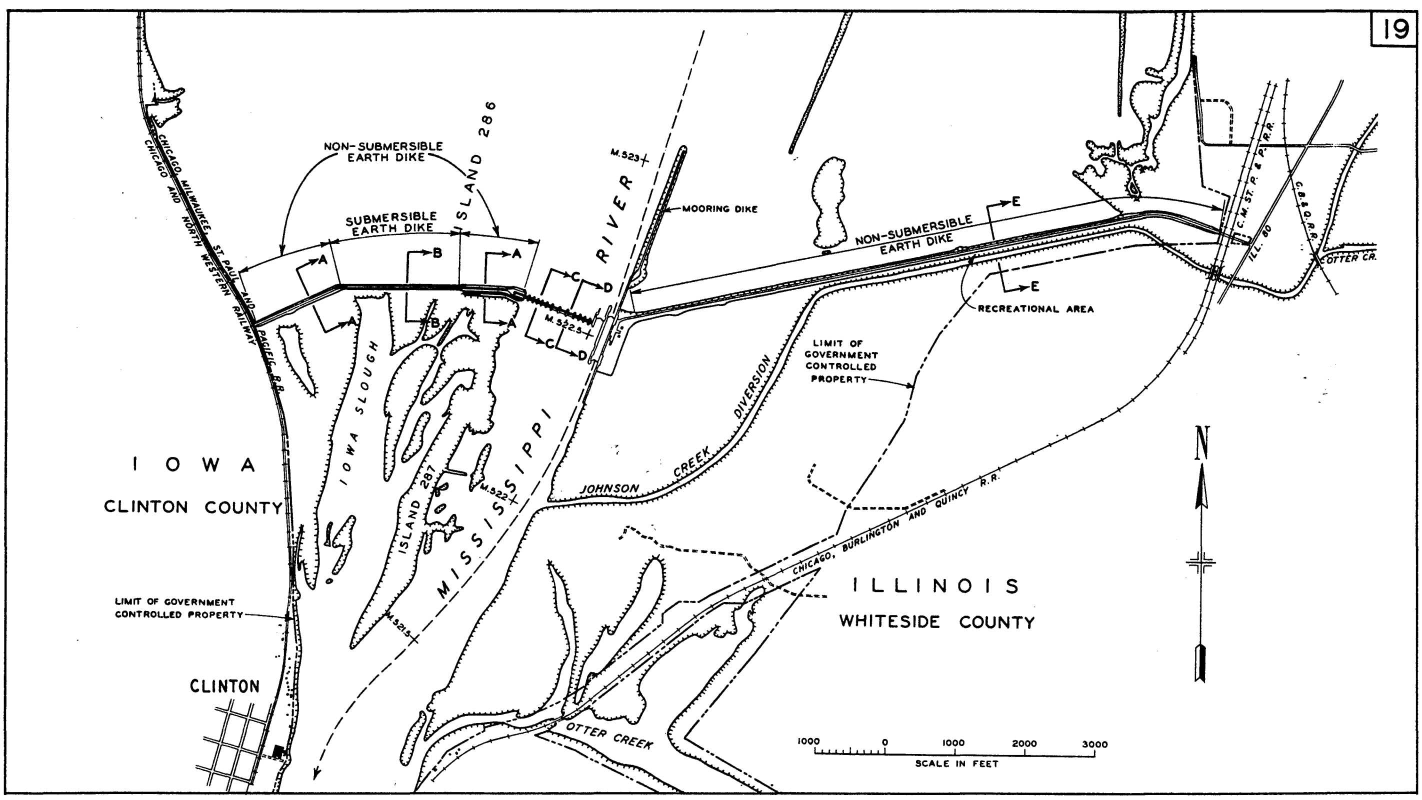
History/Significance: The lock and dam elements of the complex were completed at a cost of $5,621,000. During the peak of construction, a maximum of 1,217 men were employed at one time.

General Contractors:
Lock: James Stewart Corporation, Chicago, Illinois
Dam: Warner Construction Company, Chicago, Illinois[23]



(Above) Lock and Dam No. 13. (Peter A. Rathbun)

(Below) Site Plan, Lock and Dam No. 13. (U.S. Army Corps of Engineers, Rock Island District)



Lock and Dam No. 13

Date of Construction: 1935-1939

Location: Above Clinton, Iowa

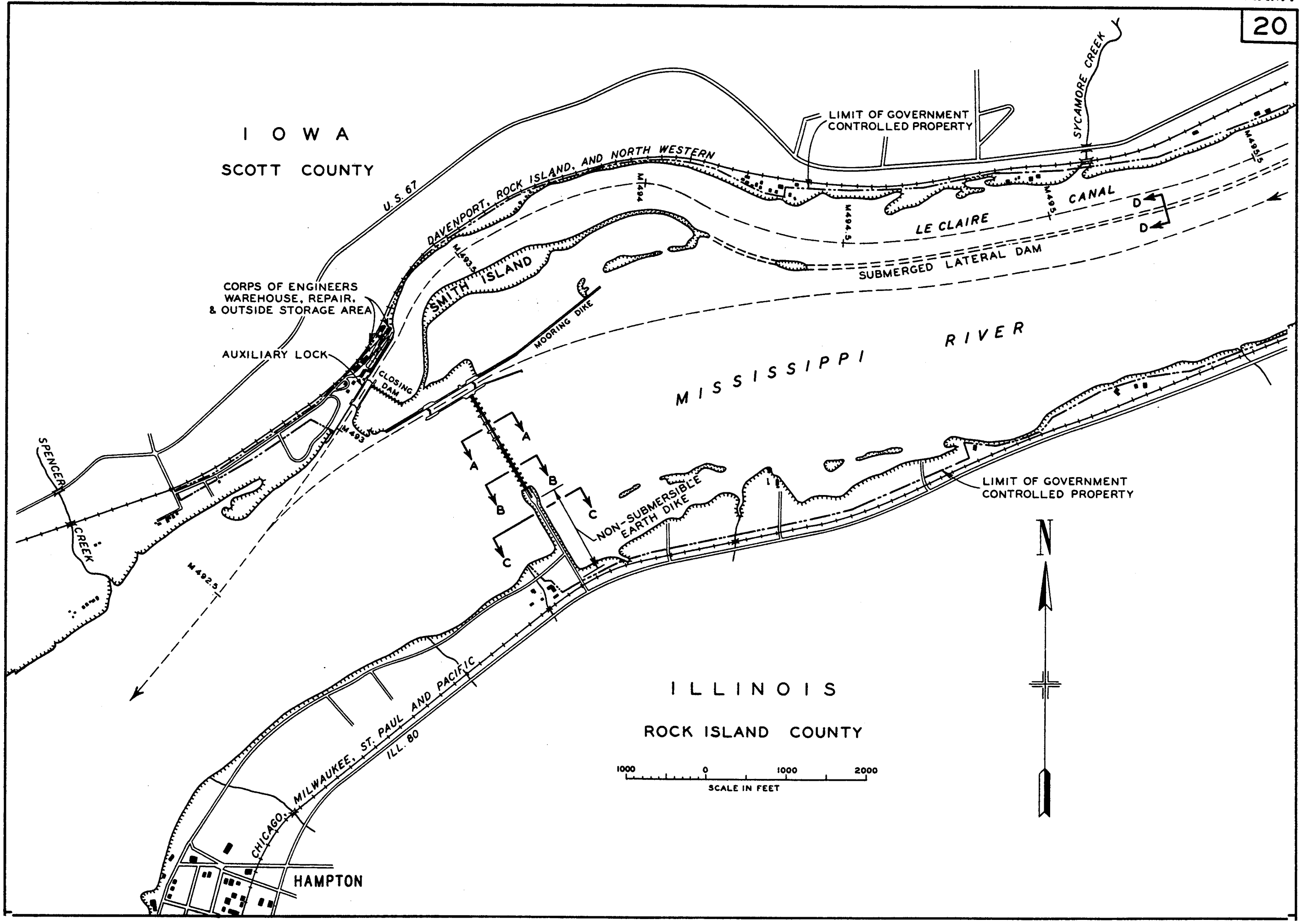
General Setting: Lock and Dam No. 13 is 522.5 miles above the confluence of the Ohio and Mississippi Rivers. The complex stretches across the river at a point where the bluffs on the Iowa side are very close to the river; islands and chutes dot the river beneath the bluffs. Eagle Point Nature Center occupies the high bluff immediately above the lock and dam. A dense group of sloughs and islands extend out from the Illinois shore.

Dam: The movable dam consists of 10 submersible Tainter gates, 20 feet high and 64 feet long; and 3 submersible roller gates, 20 feet high and 100 feet long. The Tainter gates are elliptical. The dam system also includes three non-overflow earth and sand-filled dikes; two transitional dikes; and a submersible earth and sand-filled dike.

Lock: Standard dimensions of 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 11 feet. Normal upper pool elevation is 583 feet, about 17 feet above the tail waters below the dam at low water. When both pools are at their normal elevation, the difference is reduced to 11 feet or less.

History/Significance: Locks and Dams Nos. 13, 14, and 17 were designed and built concurrently. The site for Lock and Dam No. 13 was inaccessible from the nearest highway. As a result, the general contractor constructed a dike road to the site through the sloughs, islands, and marshy bottom lands of the Illinois shore. A ferry had to be operated during the construction of the dam and central control station. It was also necessary to divert Johnson Creek so that it entered the river downstream from the lock site. The lock and dam elements of the complex were completed at a cost of $8,276,000.

General Contractors:
Lock and Dam: McCarthy Improvement Company, Davenport, Iowa[24]



(Above) Site Plan, Lock and Dam No. 14. (U.S. Army Corps of Engineers, Rock Island District)

(Below) Aerial view of Lock and Dam No. 14. (U.S. Army Corps of Engineers, Rock Island District)

Lock and Dam No. 14

Date of Construction: 1935-1940

Location: Below Le Claire, Iowa

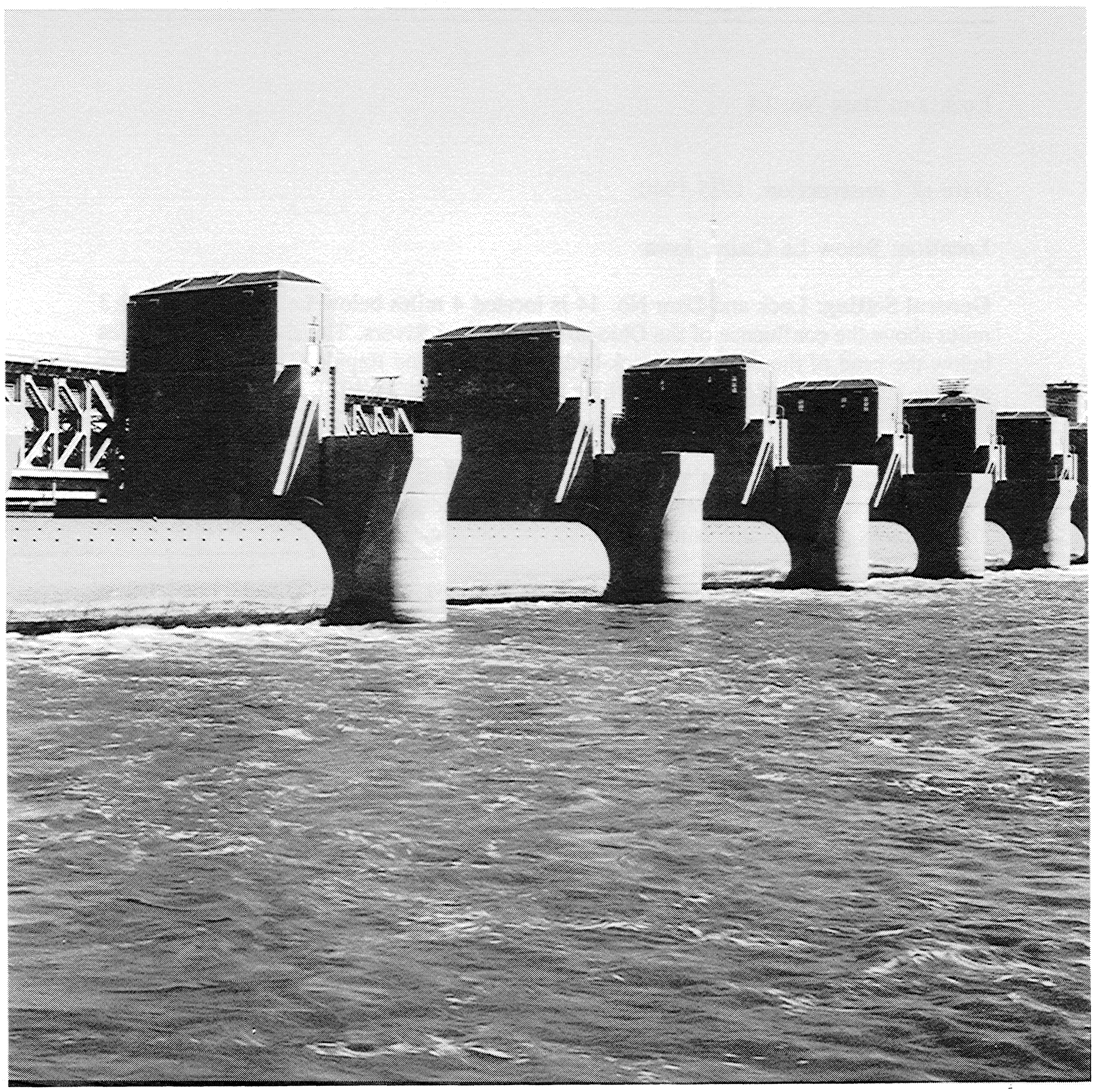
General Setting: Lock and Dam No. 14 is located 4 miles below Le Claire, and 493.3 miles above the confluence of the Ohio and Mississippi Rivers. The site is also 3.6 miles below the head of the notorious, rock-bedded, Rock Island Rapids. The Le Claire Lock and the remains of the Le Claire Lateral Canal, built in 1921-1924 to bypass this treacherous stretch of river, are located along the Iowa shore.

Dam: The movable dam has 13 non-submersible Tainter gates, 20 feet high and 60 feet long; and 4 submersible roller gates, 20 feet high and 100 feet long. The dam system also includes an earth and sand-filled dike.

Lock: The main lock's dimensions are the standard 110 by 600 feet. Lock lift is 11 feet. Normal upper pool elevation is 572 feet, about 15 feet above the tail waters of the dam at low water. When both pools are at their normal elevation, the difference is reduced to 11 feet or less. The dimensions of the Le Claire Lock, which is used as an auxiliary lock, are 80 by 320 feet, with a low water depth of 8 feet at the upper sill and 7 feet at the lower sill.

History/Significance: The Corps built the oldest elements of this complex between 1921 and 1924 during the 6-foot channel project. As part of that channelization, the Corps built a longitudinal dam parallelling the Iowa shore from the head of the Rock Island Rapids at Le Claire, to the head of Smith's Island. The dam formed the riverward wall of the Le Claire Canal, by which vessels could bypass the rapids. The Iowa shore served as the canal's landwall. Most of the longitudinal dam was submerged when Dam No. 14 was built; however, a portion of the original canal near the dam is still used as a mooring and storage site. The 9-foot channel lock and dam elements of the complex were built at a cost of $5,472,000.

General Contractors:
Lock and Dam: Central Engineering Company, Davenport, Iowa[25]



Dam No. 15 was the first 9-Foot Channel Project constructed, and features 11 non-submersible roller gates. (Peter A. Rathbun)

Lock and Dam No. 15

Date of Construction: 1931-1934

Location: Rock Island and Moline, Illinois; and Davenport and Bettendorf, Iowa

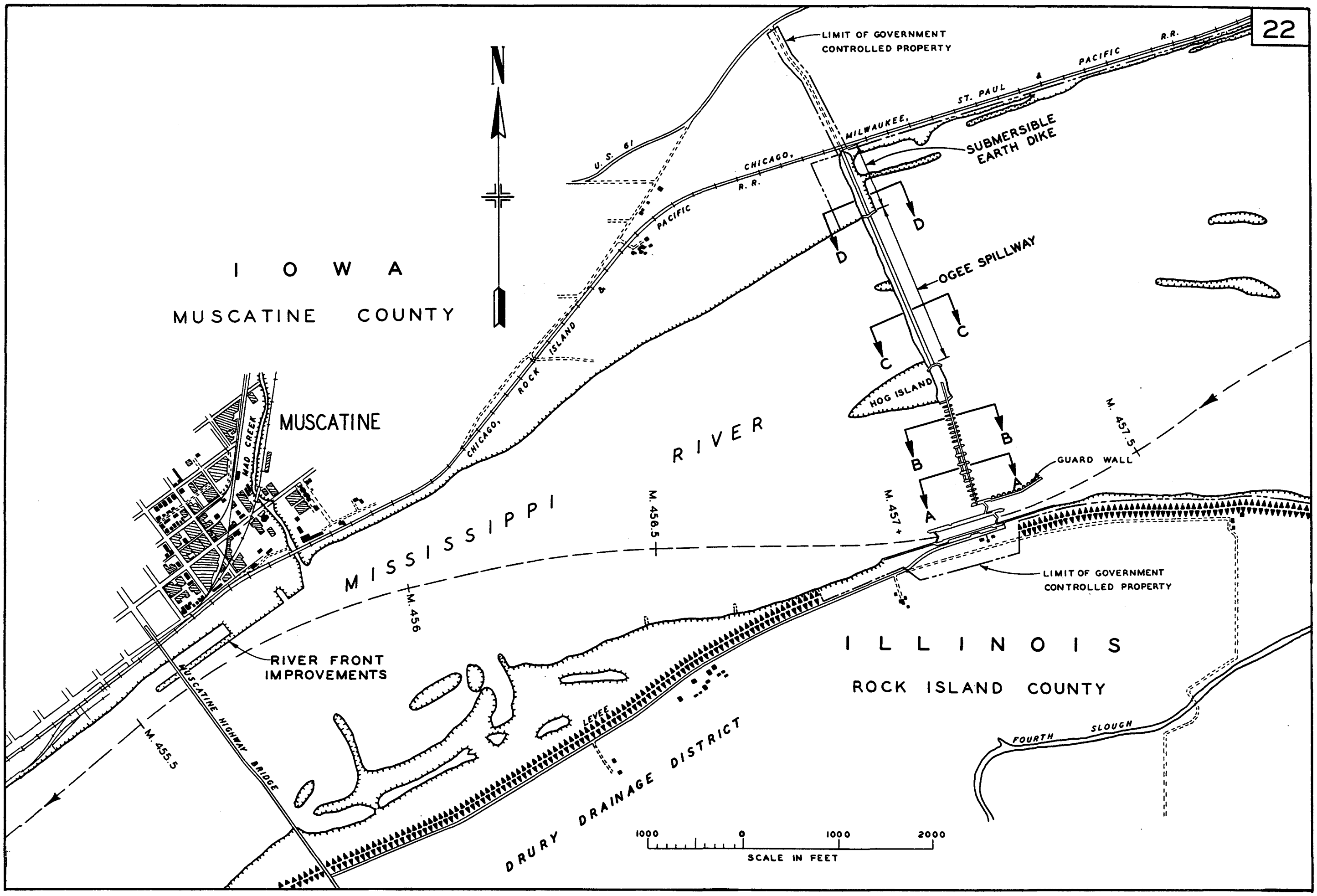
General Setting: In the heart of the Quad Cities, Lock and Dam No. 15 stretches across the Upper Mississippi at one of its narrowest points, a point which is also at the foot of the Rock Island Rapids. The complex extends from the northwest tip of the U.S. Army's Arsenal Island on the Illinois side, to a small area of flat bottom land on the Iowa side. A highway and railroad bridge, joining Davenport and Rock Island, spans the site.

Dam: The movable dam has 11 non-submersible roller gates, each 100 feet long. Nine of the gates have 19-foot 4-inch diameters; 2 of the gates have 16-foot 2-inch diameters.

Lock: Standard dimensions of 110 by 600 feet; the auxiliary lock is 110 by 360 feet. Lift on both locks is 16 feet. Normal upper pool elevation is 561.0.

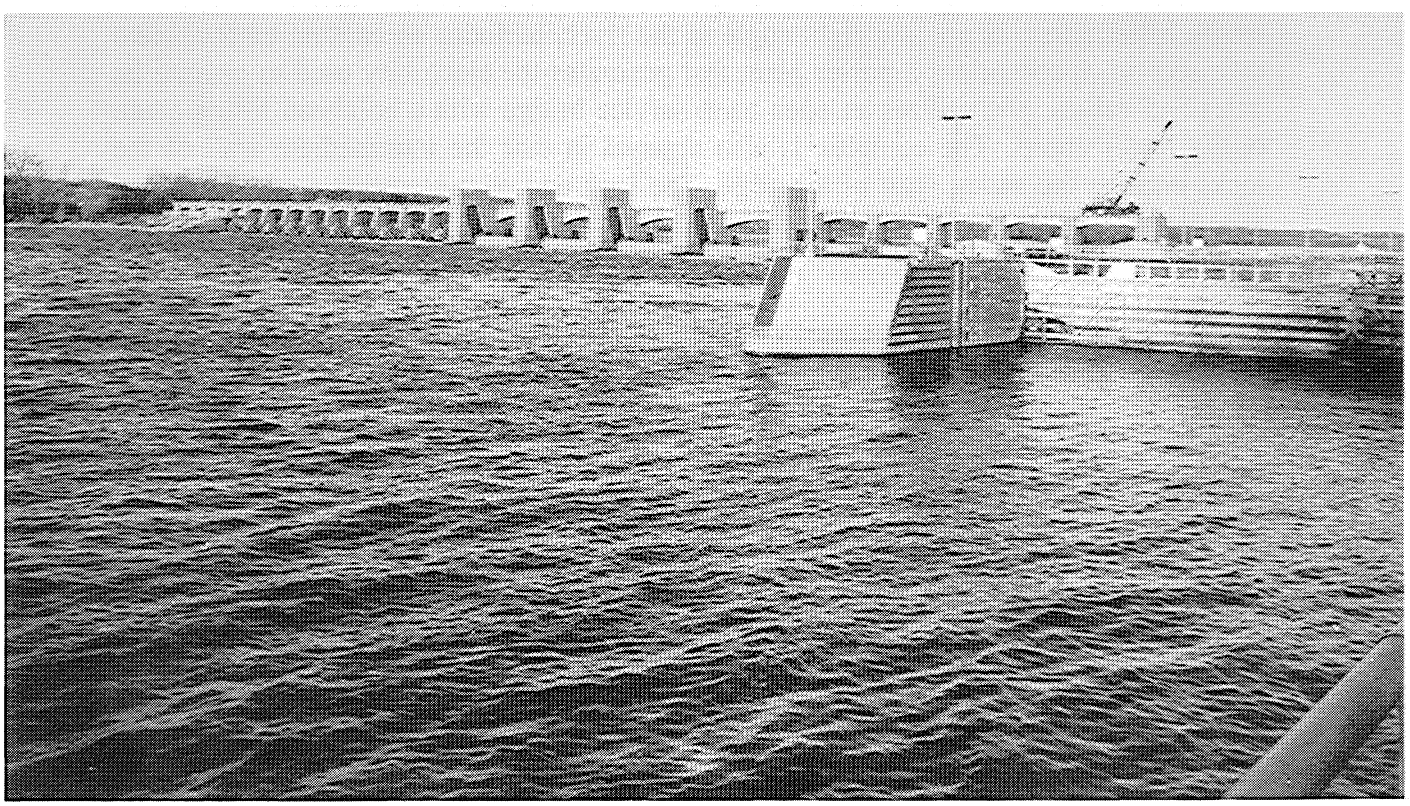
History/Significance: Lock and Dam No. 15 was the first 9-Foot Channel Project complex, and served as a prototype for the whole system. Still, Dam No. 15 is unusual among the project structures. It is composed entirely of roller gates, employs only non-submersible roller gates, has roller gates of differing sizes, contains non-standard length roller gates, is not at a right angle to the river, includes no earthen embankment dike section, incorporates a power plant that generates the electricity used to operate its gates and valves, and utilizes an open truss service bridge with a bulkhead lifting crane on its lower chord. The complex is also unusual in that the intermediate wall of the locks encases the swing span of a bridge. The lock and dam elements were completed at a cost of approximately $7,480,000.

General Contractors:
Lock: Merritt-Chapman & Whitney Corporation, Duluth, Minnesota
Dam: S.A. Healy Company, Detroit, Michigan[26]



(Above) Site Plan, Lock and Dam No. 16 (U.S. Army Corps of Engineers, Rock Island District)

(Below) Lock and Dam No. 16. (Peter A. Rathbun)



Lock and Dam No. 16

Date of Construction: 1933-1937

Location: Near Muscatine, Iowa

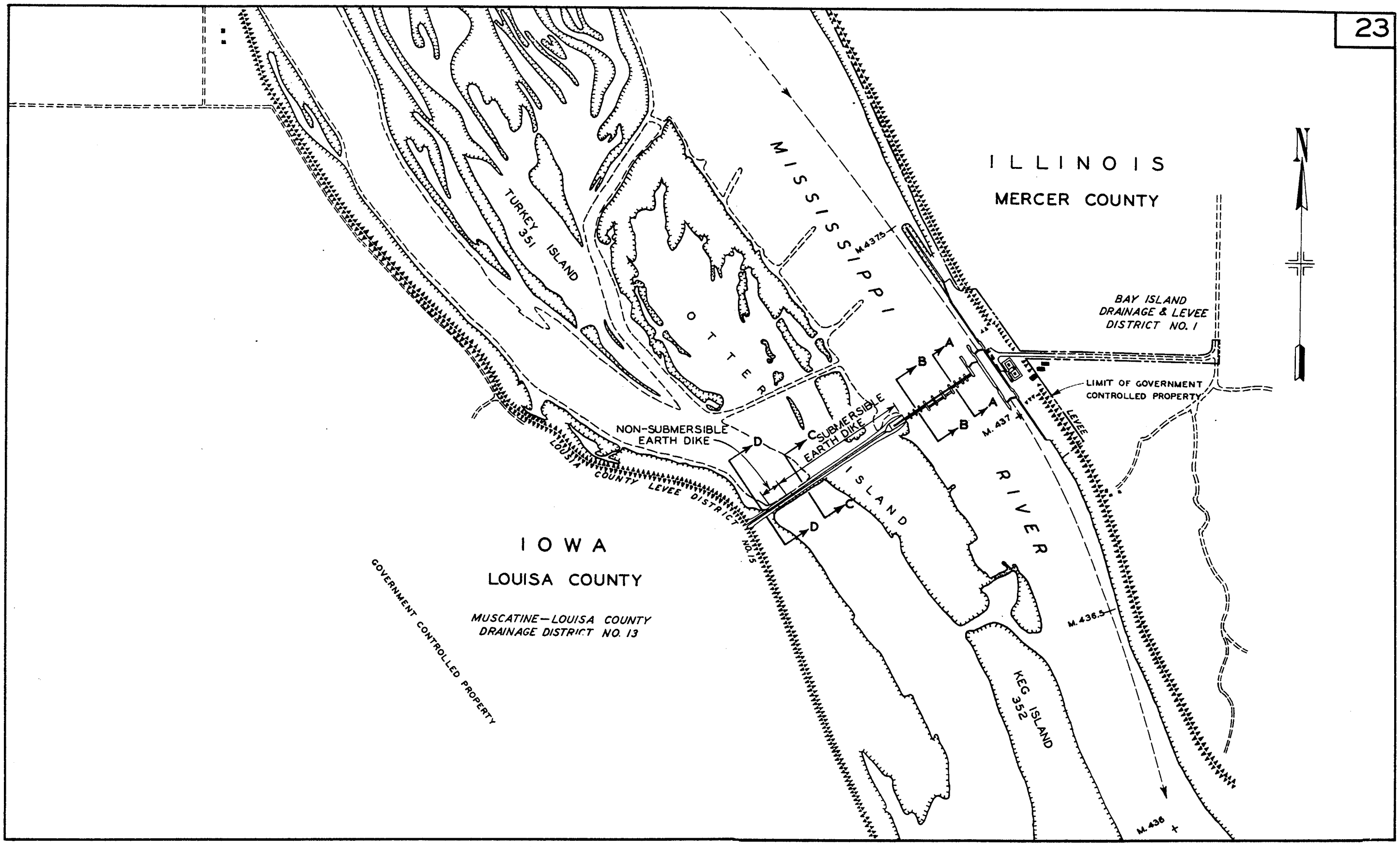
General Setting: Lock and Dam No. 16 is located about 1 mile upstream from Muscatine, and 457.2 miles above the confluence of the Ohio and Mississippi Rivers. The complex stretches across the river at a point where the valley is wide. The earthen embankment section of the dam straddles portions of Hog Island in the main channel.

Dam: The movable dam has 12 non-submersible Tainter gates, each 20 feet high and 40 feet long; 3 submersible Tainter gates of the same dimensions; and 4 non-submersible roller gates, 20 feet high and 80 feet long. The dam system also includes a linear, concrete capped, ogee spillway; and a submersible earth and sand-filled dike.

Lock: Lock dimensions are the standard 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 9 feet. Normal upper pool elevation is 545.0; about 14 feet above the tail waters below the dam at low water. When both pools are at their normal elevation, the difference is reduced to 9 feet or less.

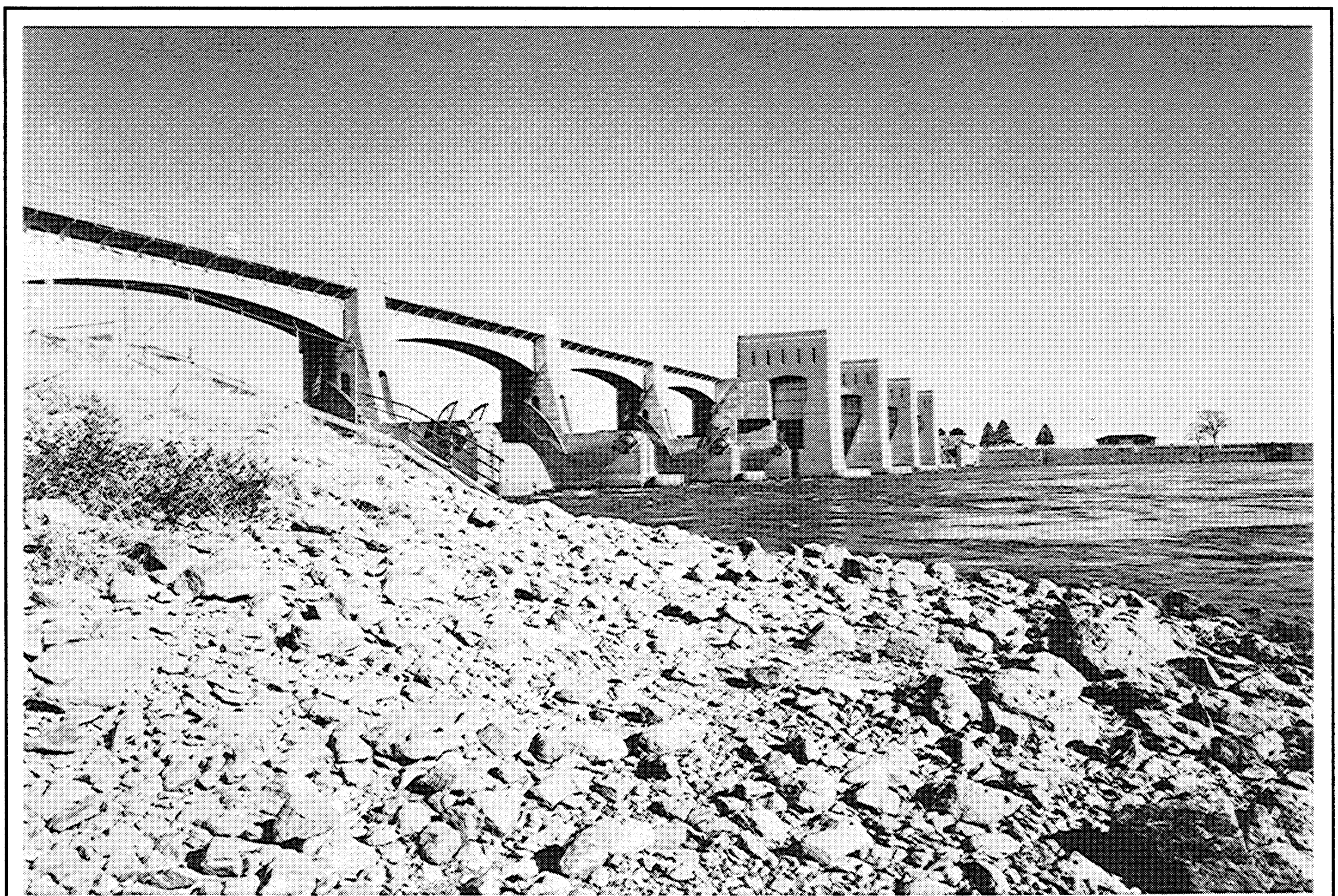
History/Significance: Dam No. 16 was the last dam in the Rock Island District to employ non-submersible roller gates, as well as Tainter gates, submersible and non-submersible, which had steel sheeting on only one side. It was also, however, the first dam in the district in which all the Tainter gates were operated by line shafts and motors housed in installations above each gate, rather than from locomotive hoist cars running on the dam's service bridge. The lock and dam elements were completed at a cost of $5,688,000.

General Contractors:
Lock and Dam: Central Engineering Company, Davenport, Iowa[27]



(Above) Site Plan, Lock and Dam No. 17.

(Below) Lock and Dam No. 17. (Peter A. Rathbun)



Lock and Dam No. 17

Date of Construction: 1935-1939

Location: Near New Boston, Illinois

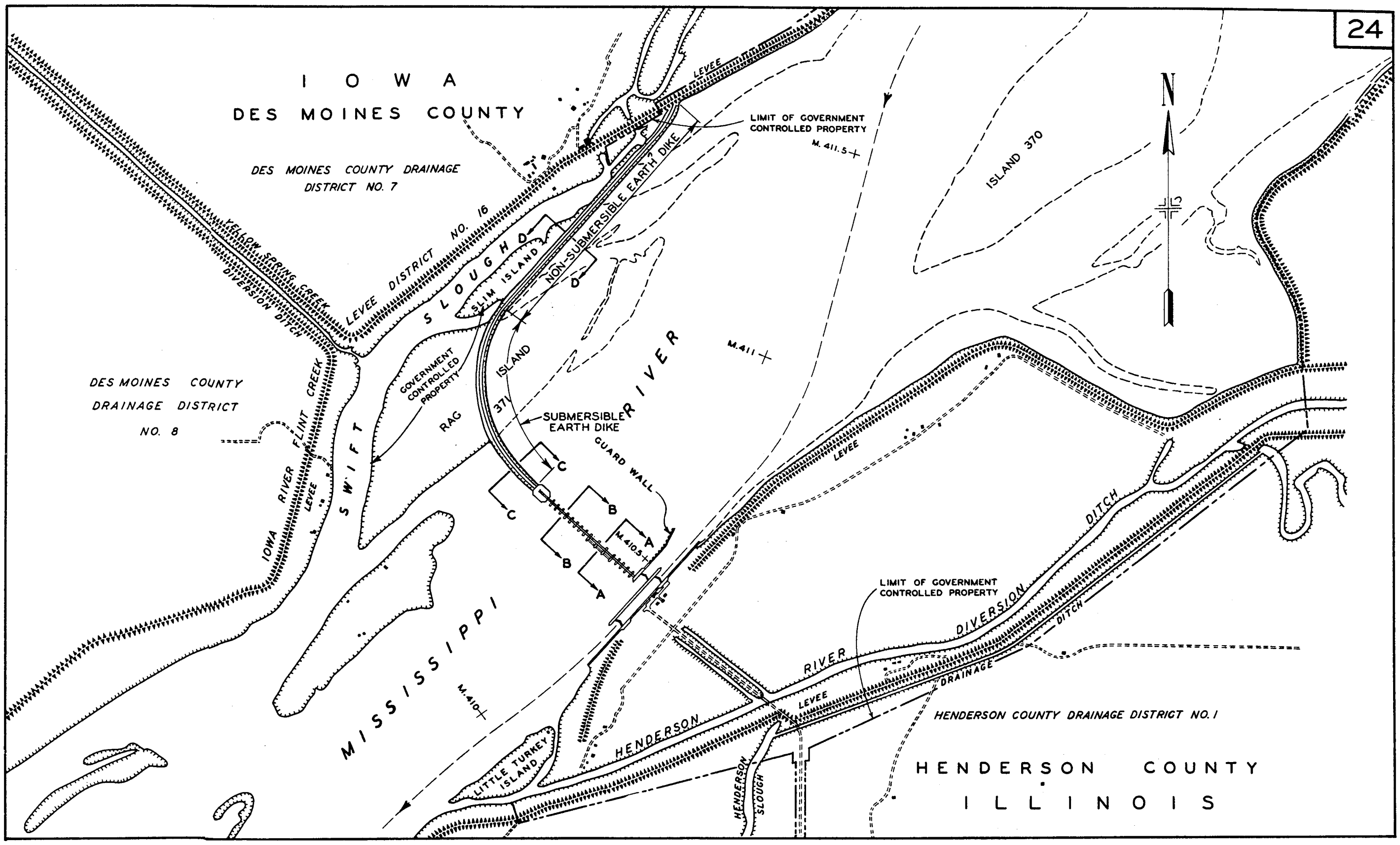
General Setting: Lock and Dam No. 17 is 437.1 miles above the confluence of the Ohio and Mississippi Rivers. The complex stretches across a wide portion of river where there are several marshy islands. The Upper Mississippi River Wildlife and Fish Refuge occupies the islands, marshes, and sloughs on the Iowa shore both upstream and downstream from the dam.

Dam: The movable dam has 8 submersible Tainter gates, 20 feet high and 64 feet long; and 3 submersible roller gates, 20 feet high and 100 feet long. The dam system also includes one non-overflow earth and sand-filled dike; two transitional dikes; and a submersible earth and sand-filled dike.

Lock: Standard dimensions of 110 by 600 feet, with footings for an auxiliary lock. Lock lift is 8 feet. Normal upper pool elevation is 536.0, about 12 feet above the tail waters of the dam at low water. When both pools are at their normal elevation, the difference is reduced to 8 feet or less.

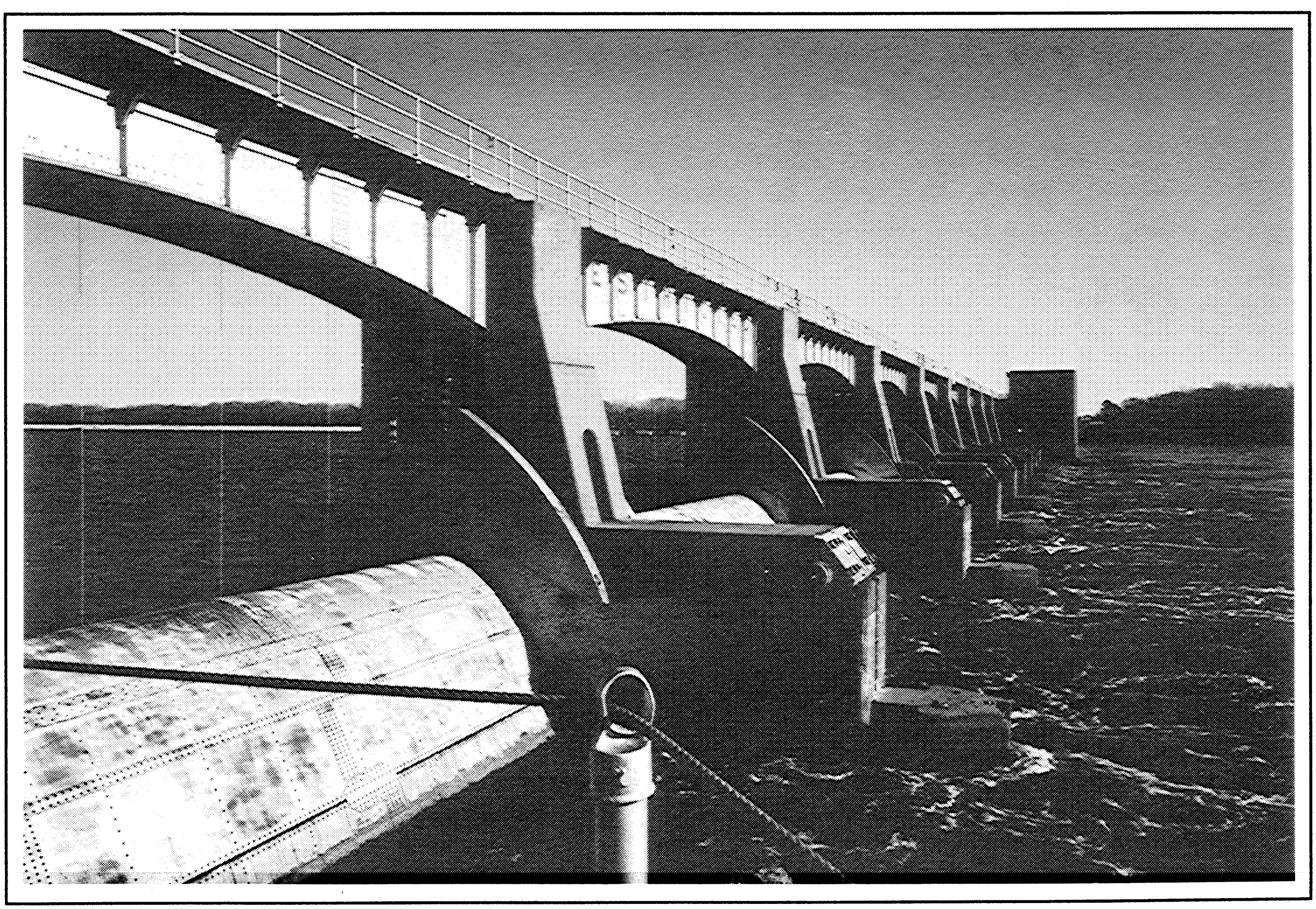
History/Significance: The site of Lock and Dam No. 17 was inaccessible from the nearest highway. As a result, the contractors for the lock had to construct a 3.7 mile long entrance road. The remoteness of the site caused other problems. Not enough workers could commute to the job site from their homes. As a result, the Massman Construction Company and the Massman-Peterman Company built a workers' camp near the lock and dam site. This camp consisted of eleven 16-man bunk houses and a large mess hall. During the peak of construction in July 1936, 626 men were employed on the project. The lock and dam elements were built at a cost of $5,638,000.

General Contractors:
Lock: Massman Construction Company and Massman-Peterman Company,
Kansas City, Missouri
Dam: Maxon Construction, Dayton, Ohio[28]



(Above) Site Plan, Lock and Dam No. 18.

(Below) Tainter Gates, Dam No. 18. (Peter A. Rathbun)



Lock and Dam No. 18

Date of Construction: 1934-1937

Location: Seven miles above Burlington, Iowa

General Setting: The complex is 410.5 miles above the confluence of the Mississippi and Ohio Rivers. The bottom lands on both shores are flat and punctuated by sloughs, marshes, and reefs. The river is dotted with low islands of various sizes. The Oquawka State Wildlife Refuge is adjacent to the lock and dam complex on the Illinois shore. The installation's esplanade interrupts a levee and functions as part of the Henderson River diversion that converted Turkey Island into an extension of the Illinois shore.

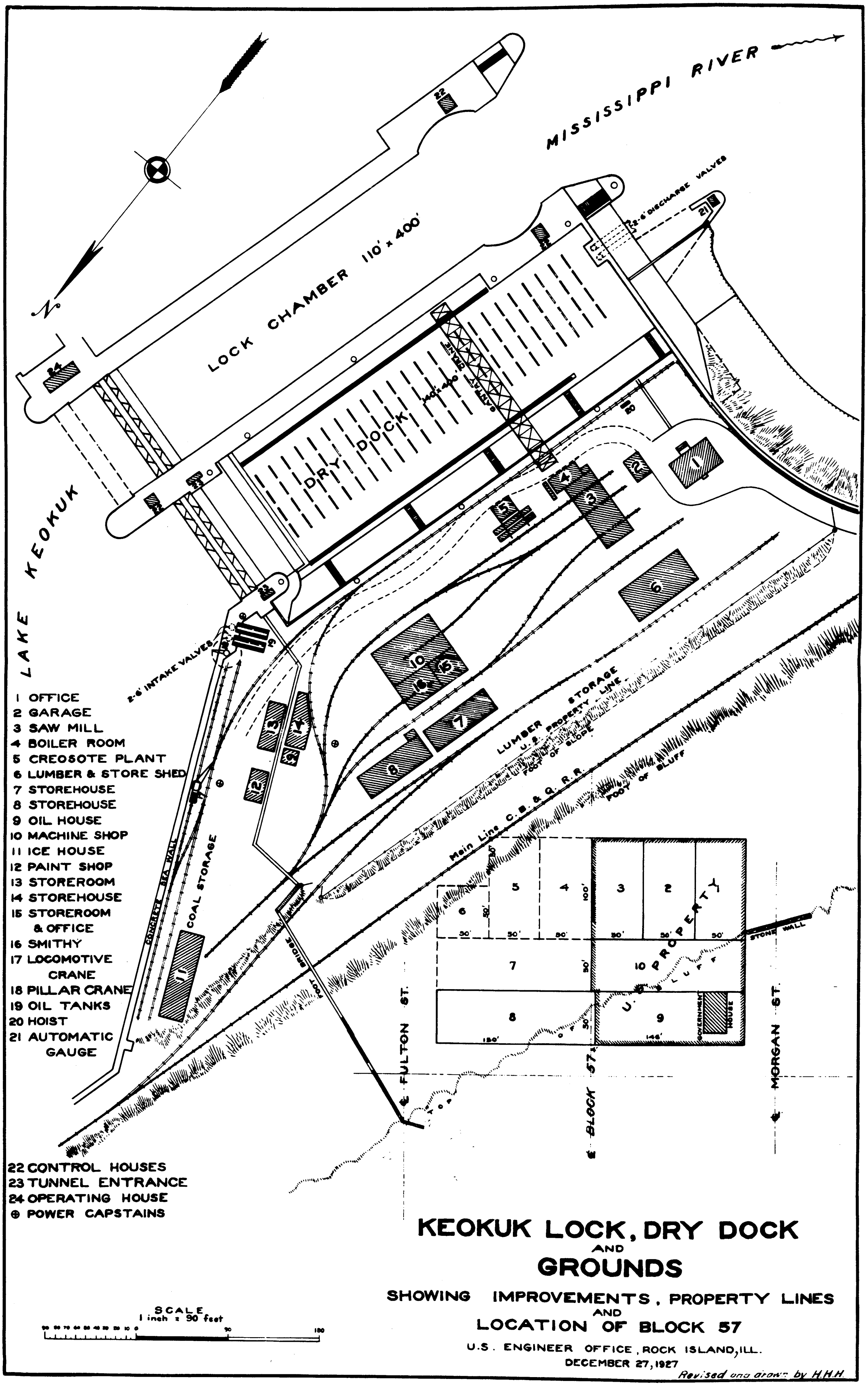
Dam: The dam system is composed of 14 submersible Tainter gates, 20 feet high and 60 feet long; and 3 submersible roller gates, 20 feet high and 100 feet long. All of the gates submerge to a depth of 8 feet. The dam system also includes a submersible earth and sand-filled dike; a non-overflow earth and sand-filled dike; and two transition dikes.

Lock: Lock dimensions are the standard 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 10.5 feet. Normal upper pool elevation is 528.0, about 13 feet above the tail waters of the dam at low water. When both pools are at their normal depth, the difference is reduced to 9.8 feet or less.

History/Significance: Dams Nos. 11 and 18 were the first in the Rock Island District to employ submersible, elliptical Tainter gates. They were also the first two dams in the district to utilize submersible roller gates. This complex also involved the diversion of Henderson River so that it entered the Upper Mississippi immediately below the lock and dam complex. The lock and dam were built at a cost of $5,886,000. During the peak of construction in September 1934, the project employed 960 men as laborers, and 74 men as supervisors. Average employment was 478 laborers and 44 supervisors.

General Contractors:
Lock: Maxon Construction Company, Dayton, Ohio
Dam: S.A. Healy Company, Chicago, Illinois[29]

Lock and Dam No. 19



Lock and Dam No. 19

Date of Construction: (1910-1914) 1952-1957

Location: Keokuk, Iowa

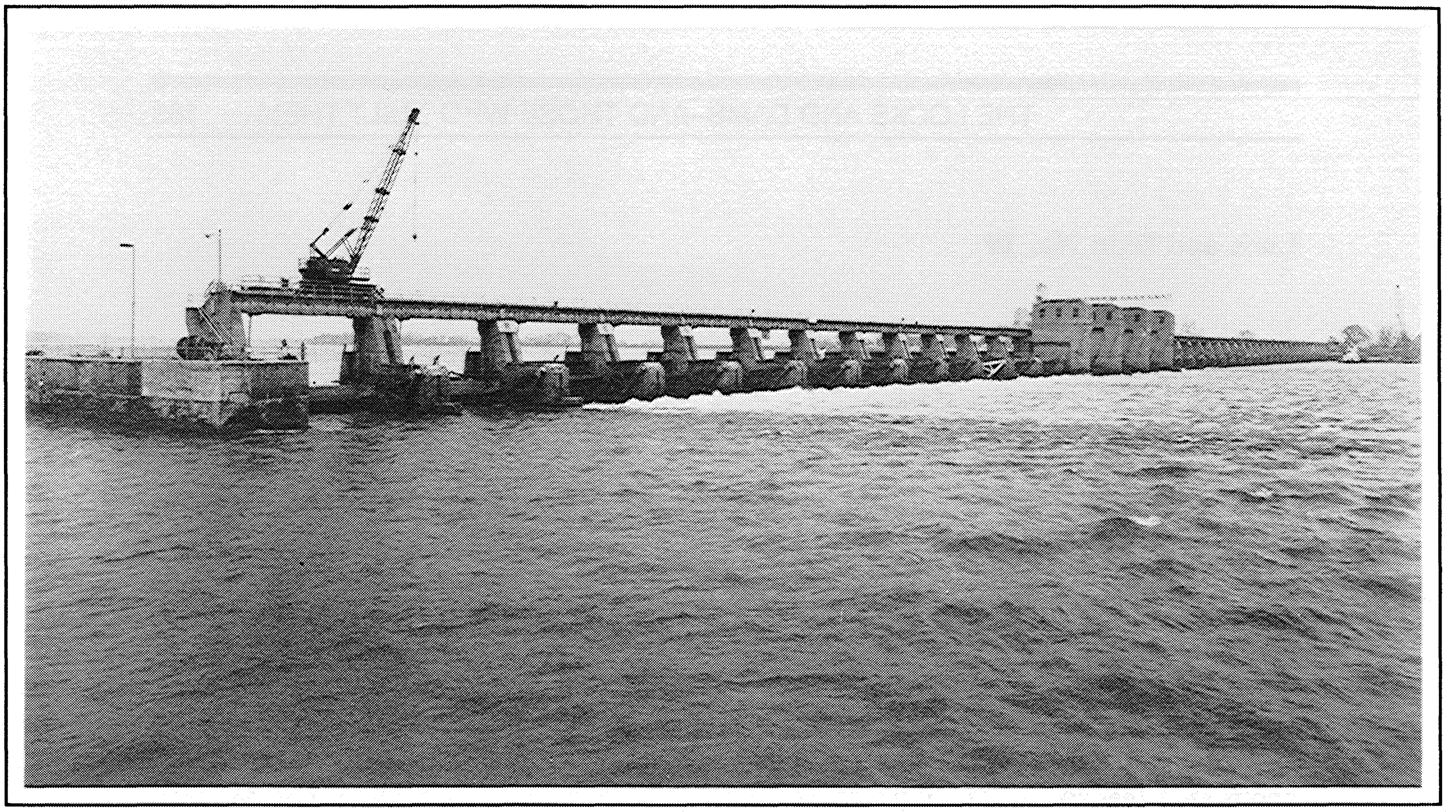
General Setting: The complex is 364.2 miles above the confluence of the Ohio and Mississippi Rivers.

Dam: Privately built and owned, the dam was built in 1913 and includes 119, rectangular, sliding gates.

Lock: Constructed between 1952-1957, the main lock is 110 by 1,200 feet, twice the size of the standard 9-foot channel lock. Normal upper pool elevation is 518.2 feet; about 38.2 feet above the tail waters of the dam at low water. The Keokuk and Hamilton Water Power Company Lock, built between 1910 and 1914, is closed off by a permanent, steel pile, cell structure.

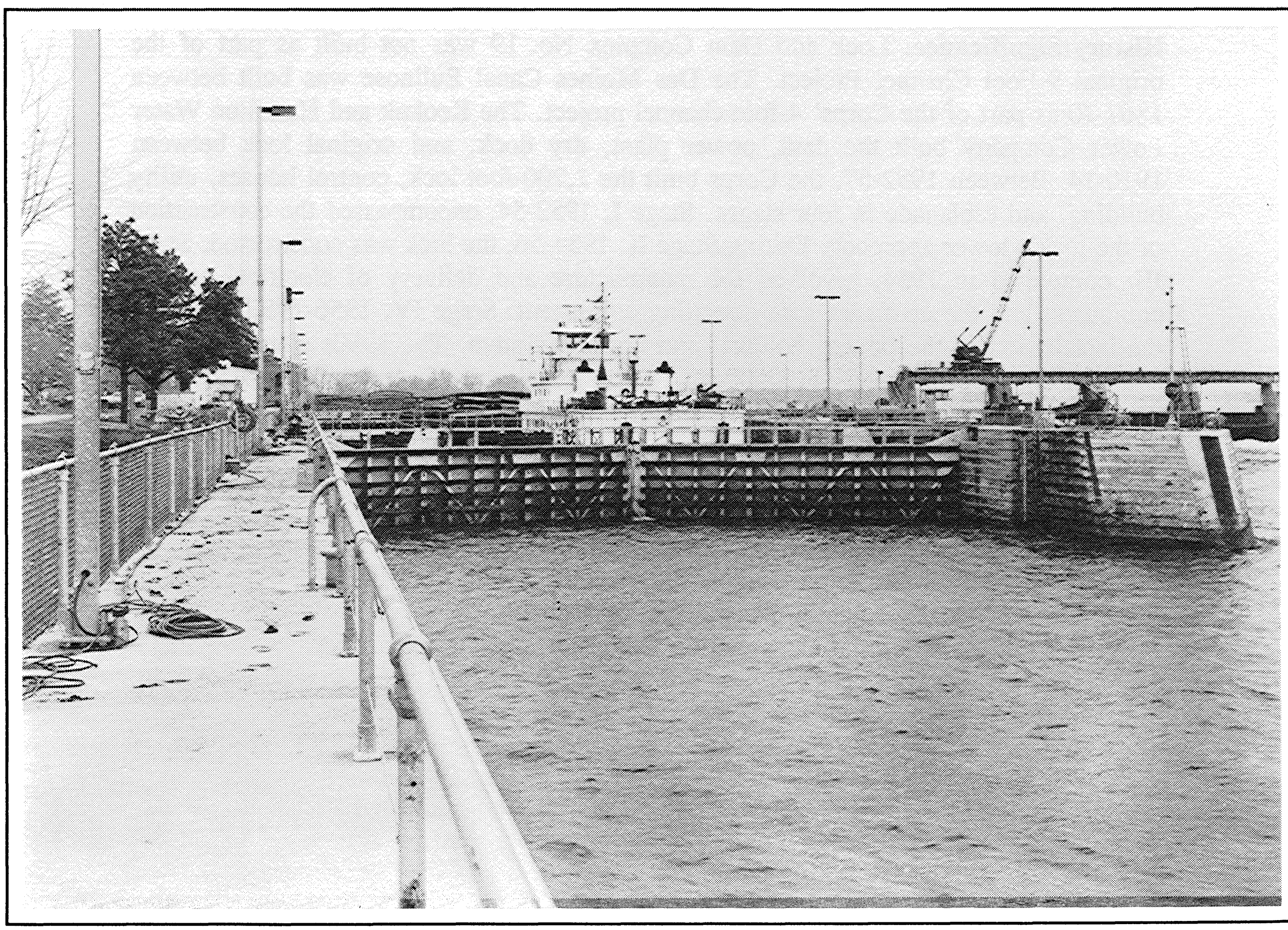
History/Significance: Lock and Dam Complex No. 19 was not built as part of the original 9-Foot Channel Project. The Des Moines Canal Bullnose was built between 1867-70 as part of the Corps' 4-foot channel project. The Keokuk and Hamilton Water Power Company built the dam, power plant, dry dock, and original lock between 1910-14. Between 1952-57, the Corps built the 1,200-foot lock, control houses, utility building, and esplanade in four stages. Stage I, 1952-54, encompassed the construction of the lock's lower approach. During Stage II, 1954-56, the lock was constructed. Stage III, completed in 1954, involved the manufacture and delivery of electrical control equipment and the upstream gate operating equipment. Stage IV, 1956-1957, included the installation of the power, control, and lighting system. The 1950s elements of the complex cost approximately $13,500,000. During the peak of construction, 415 people were employed. Elements of Lock and Dam No. 19 were listed on the National Register of Historic Places in October 1978.

General Contractors:
Stage I: McCarthy Improvement Company, Davenport, Iowa
Stage II: Jones Construction Company, Charlotte, North Carolina
Stage III: Oil Gear Company, Milwaukee, Wisconsin
Stage IV: Evans Electrical Construction Company, Omaha, Nebraska[30]



(Above) Lock and Dam No. 20. (Peter A. Rathbun)

(Below) Lock No. 20, Downstream View. (Peter A. Rathbun)



Lock and Dam No. 20

Date of Construction: 1932-1935

Location: Between Canton, Missouri, and Meyer, Illinois

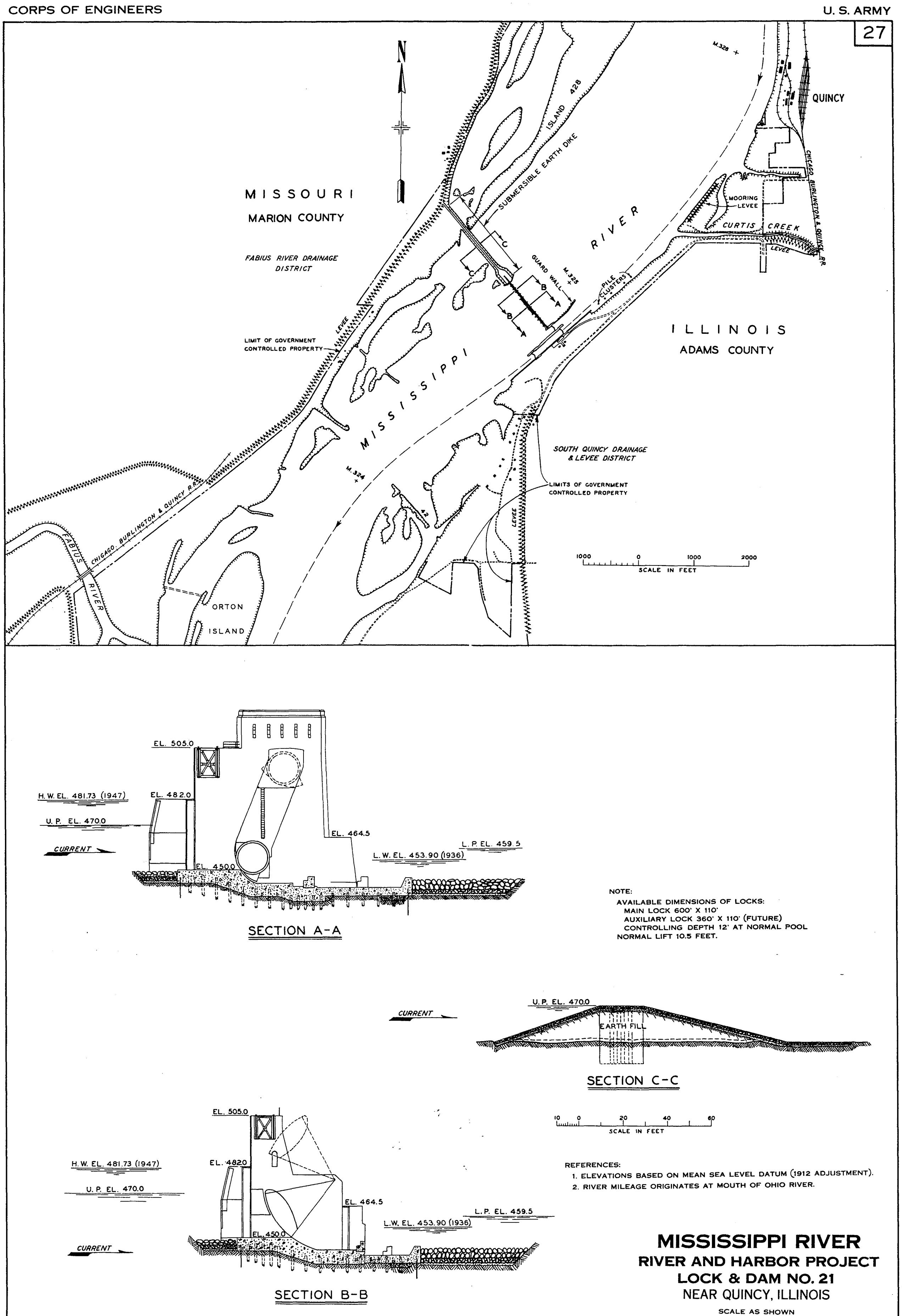
General Setting: Lock and Dam No. 20 is 343.2 miles above the confluence of the Ohio and Mississippi Rivers. The complex stretches across the river at a point where the valley is quite wide, about 5 miles wide at the level of the lock and dam. A levee and the Gregory Diversion Ditch separate the complex from the town of Canton.

Dam: The movable dam has 3 non-submersible roller gates, 20 feet high and 60 feet long; 34 non-submersible Tainter gates, 20 feet high and 40 feet long; and 6 submersible Tainter gates, 20 feet high and 40 feet long. The submersible Tainter gates submerge 3 feet.

Lock: Lock dimensions are 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 10.5 feet. Normal upper pool elevation is 480.0; this is about 15 feet above the tail waters of the dam at low water. When both pools are at their normal depths, the difference is reduced to 10 feet or less.

History/Significance: Dam No. 20 was the first dam in the Rock Island District to include Tainter gates. The plans originally called for all of the Tainter gates to be operated by hoist cars traveling on the dam's service bridge. However, the district modified two Tainter gates so that they were individually operated by line shafts and motors housed in installations above each gate. This operating machinery worked so well that all subsequent Tainter gates in the 9-Foot Channel Project, regardless of which district they were in, utilized line shafts and motors. The lock and dam elements of complex No. 20 cost $4,450,000. In 1986, Lock and Dam No. 20 became the first complex in the Rock Island District to undergo major rehabilitation.

General Contractors:
Lock: Maxon Construction Company, Dayton, Ohio
Dam: S.A. Healy Company, Detroit, Michigan, and Davenport, Iowa[31]



Site Plan, Lock and Dam No. 21.

Lock and Dam No. 21

Date of Construction: 1933-1939

Location: Quincy, Illinois

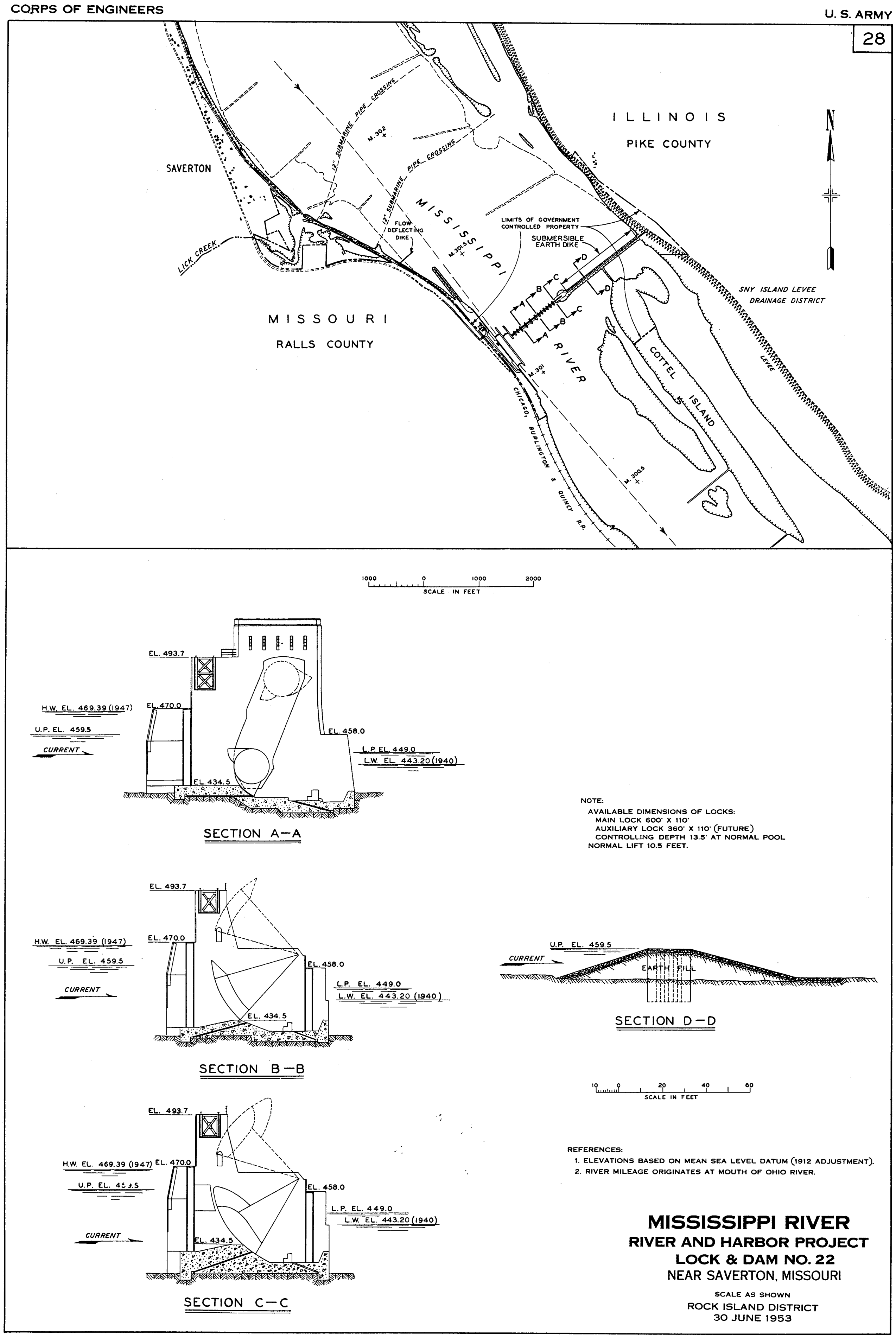
General Setting: Lock and Dam No. 21 is located 324.9 miles above the confluence of the Ohio and Mississippi Rivers. The complex stretches across the river at a point where the valley is wide with flat bottom land on either side of the river. The city of Quincy lies on the low bluffs along the river just upstream from the complex.

Dam: The movable dam has 10 submersible, elliptical Tainter gates, 20 feet high and 64 feet long; and 3 submersible roller gates, 20 feet high and 100 feet long. The dam system also includes two earth and sand-filled transitional dikes, and a submersible earth dike.

Lock: Lock dimension are the standard 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 10.5 feet. Normal upper pool elevation is 470.0; approximately 16 feet above the tail waters of the dam at low water. When both pools are at their normal depths, the difference in elevation is reduced to 11 feet or less.

History/Significance: Lock and Dam No. 21 was a group "D" priority. However, because it was located adjacent to Quincy, Illinois--which had an acute unemployment problem--the installation was built before some of the other, higher priority installations in the Rock Island District. The lock, central control station, and esplanade were completed by August 1935. At that point, however, there was no money available with which to begin the dam. As a result, representatives from Quincy began to vigorously--and successfully--lobby for Federal money to construct the dam as a work relief project. The lock and dam elements were completed at a cost of $5,721,000.

General Contractors:
Lock: Joseph Meltzer Inc., New York, New York
Dam: McCarthy Improvement Company, Davenport, Iowa[32]



Site Plan, Lock and Dam No. 22.

Lock and Dam No. 22

Date of Construction: 1934-1939

Location: Saverton, Missouri

General Setting: Lock and Dam No. 22 is located 301.2 miles above the confluence of the Ohio and Mississippi Rivers. Bluffs rise over 200 feet above the river west of the lock; east of complex the valley is quite wide.

Dam: The movable dam has 9 non-submersible Tainter gates, 25 feet high and 60 feet long; 1 submersible Tainter gate, 25 feet high and 60 feet long; and 3 submersible roller gates, 25 feet high and 100 feet long. Completing the dam system are two transition dikes, and a submersible earth and sand-filled dike.

Lock: Lock dimensions are the standard 110 by 600 feet, with additional footings for an auxiliary lock of standard dimensions. Lock lift is 10.5 feet. Normal upper pool elevation is 459.5, about 16.5 feet above the tail waters of the dam at low water. When both pools are at their normal depths, the difference in elevation is reduced to 10.5 feet or less.

History/Significance: It was on the submersible roller gates at Dam No. 22 that the Rock Island District introduced Poiree dam trestles to mitigate scour problems. The trestles were subsequently used as a retrofit solution on other project dams. It was also on this dam's submersible roller gates that the St. Paul District Hydraulic Laboratory conducted the tests that led to the design of stilling basins for roller gates. The Rock Island District also incorporated an experimental design for a submersible roller gate with end shields at Dam No. 22. Additionally, the Rock Island District introduced a new type of non-submersible, truss-type Tainter gate in Dam No. 22. The lock and dam elements were built at a cost of $5,135,000. During the peak of construction, 959 people were employed on the installation.

General Contractors:
Lock: Joseph Meltzer, Inc., New York, New York
Dam: Massman Construction Company, Kansas City, Missouri[33]

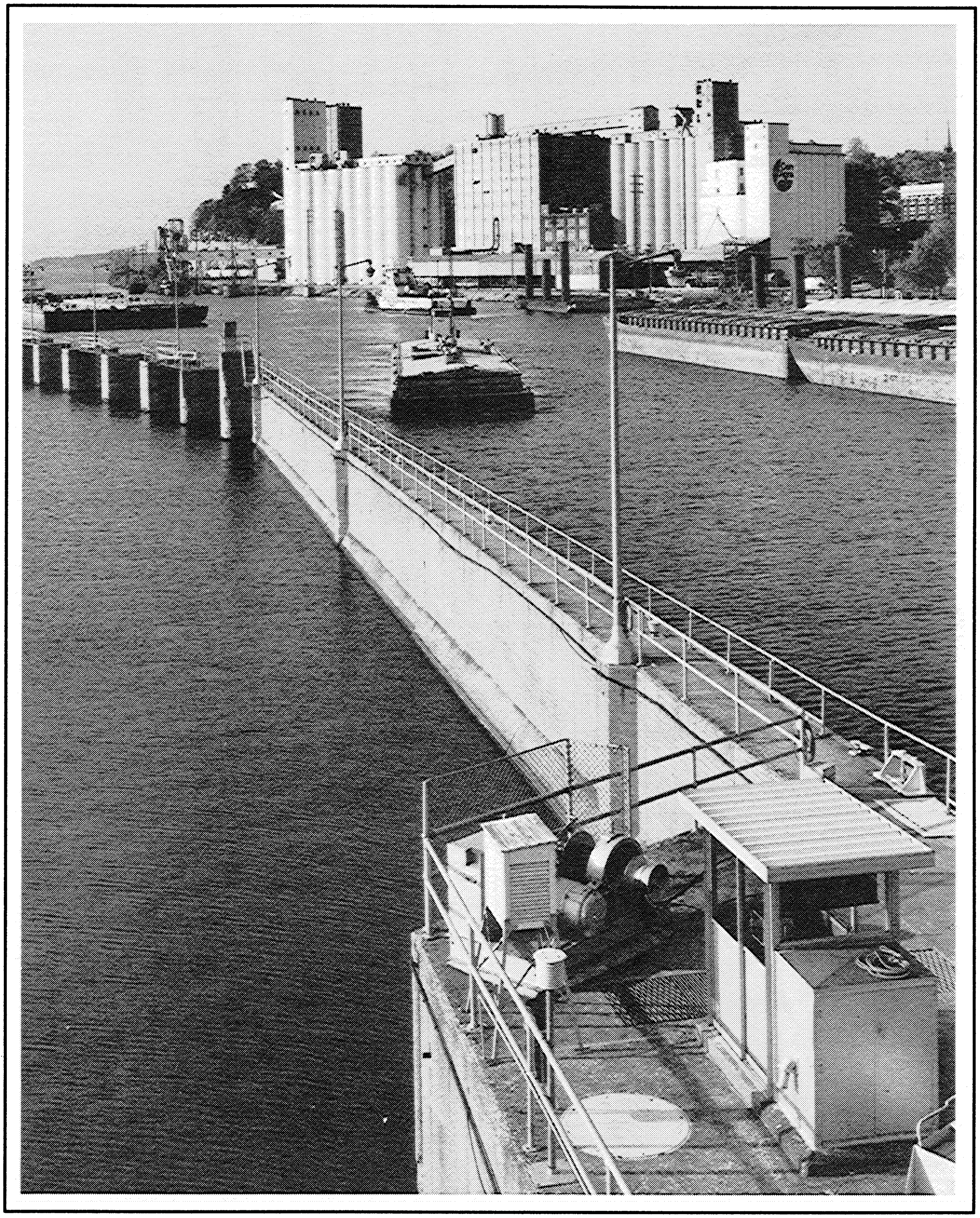
The St. Louis District

The St. Louis District directed the 9-foot channel activities between Clarksville and St. Louis, Missouri. It also served as the headquarters of the Upper Mississippi Valley Division. The Corps of Engineers constructed Locks and Dams Nos. 24, 25, and 26 in the St. Louis District as part of the original 9-Foot Channel Project. Additionally, the Corps built two complexes after the completion of the initial project. Lock No. 27, and the associated Chain of Rocks Canal, were built between 1947 and 1953. Dam No. 27, also known as the Chain of Rocks Dam, was erected in the early 1960s. The St. Louis District was also the first district in which one of the original 9-Foot Channel Project installations was replaced. In 1990, the Corps razed Lock and Dam No. 26 following the construction of Lock and Dam No. 26R, also known as the Melvin Price Lock and Dam.

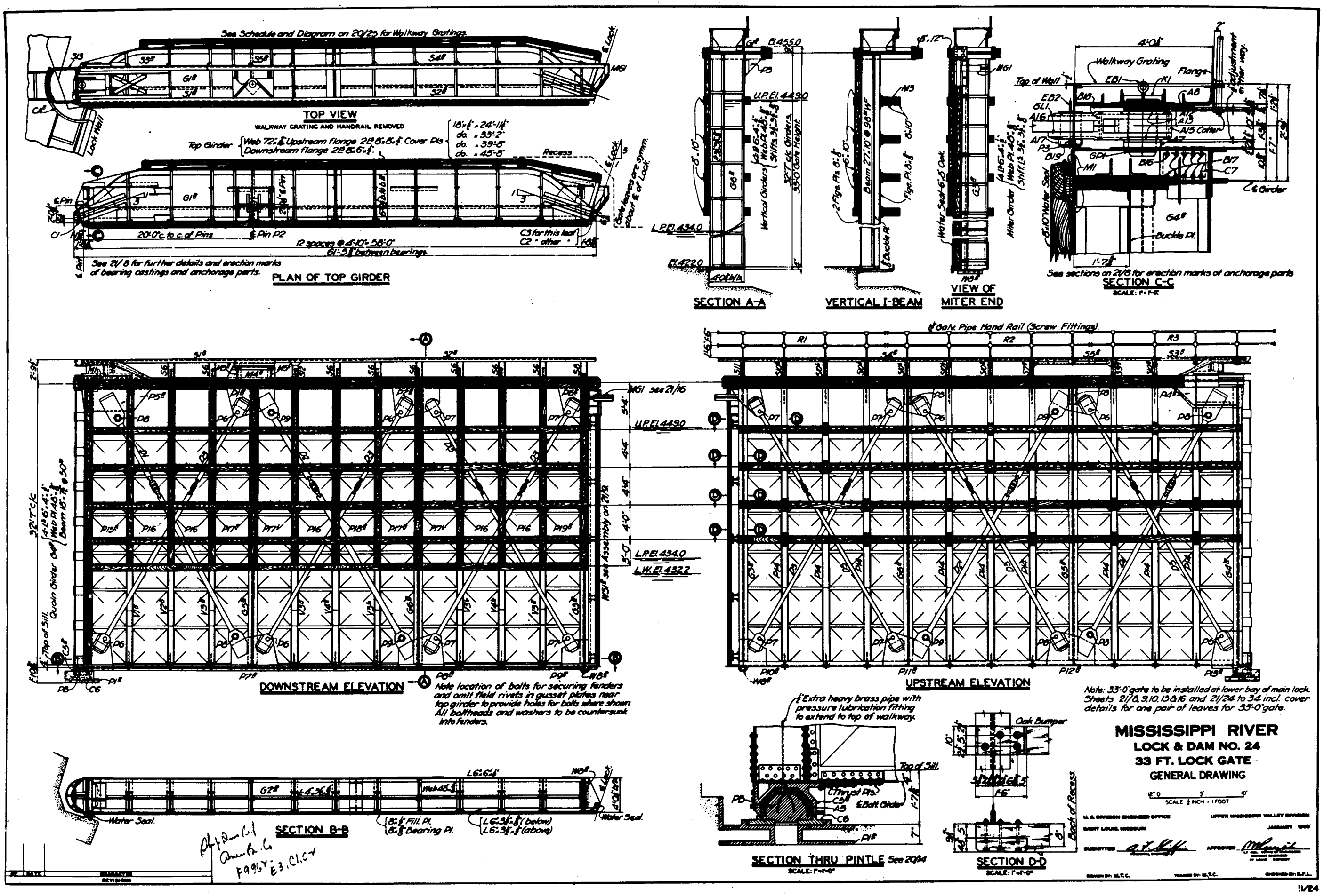
William McAlpine oversaw the design of only one 9-foot channel structure in the St. Louis District: Lock No. 26. Nevertheless, McAlpine's design work, as manifested in the lock and dam installations in the St. Paul and Rock Island Districts, provided prototypes for those constructed in the St. Louis District. After McAlpine transferred to Washington, D.C., A. Frederick Griffin, a 1914 civil engineering graduate of the Worcester Polytechnic Institute, assumed responsibility for design of the principal elements of Dam No. 26, Lock and Dam Nos. 24 and 25, and Lock No. 27.[34]

The St. Louis District oversaw all construction work at the individual installations and provided some minor design services. This work was performed by the district's lock and dam section, established by District Engineer Major William A. Snow in October 1933. Captain William W. Wanamaker headed the section, which initially consisted of four civilian engineers, two draftsmen, and a clerk. Lawrence B. Feagin, a 1922 graduate of Vanderbilt University, served as the section's Senior Engineer. Feagin was responsible for all engineering work at Lock and Dam Nos. 24-26, exclusive of the initial design work performed by the UMVD.[35]

Taken as a whole, the five Upper Mississippi River lock and dam installations in the St. Louis District provide a remarkable portrait of the evolution of river navigation improvement technology from the early 1930s to the present. The significance of these individual installations is enhanced by the important role they played in the rejuvenation of river navigation on the Upper Mississippi River.

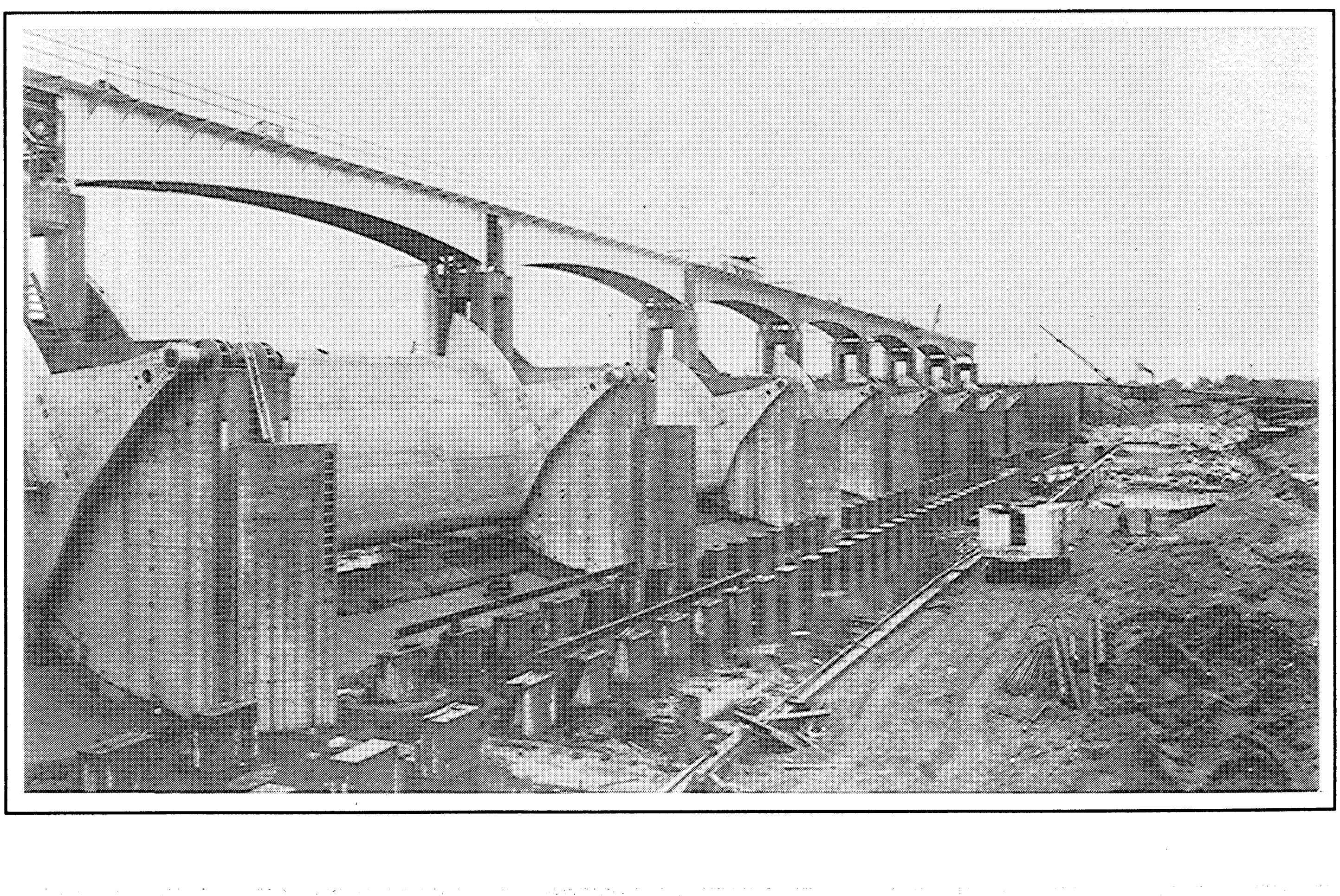


William McAlpine, head of the Upper Mississippi Valley Division (UMVD), oversaw the design of Lock No. 26. Upper Guide Wall, Lock No. 26. (John P. Herr, John Herr Photography)



(Above) Miter Gate Construction Plan, January 1936. (U.S. Army Corps of Engineers, St. Louis District)

(Below) Construction of Dam No, 24, October 1939. (U.S. Army Corps of Engineers, St. Louis District)



Lock and Dam No. 24

Date of Construction: 1936-1940

Location: Clarksville, Missouri

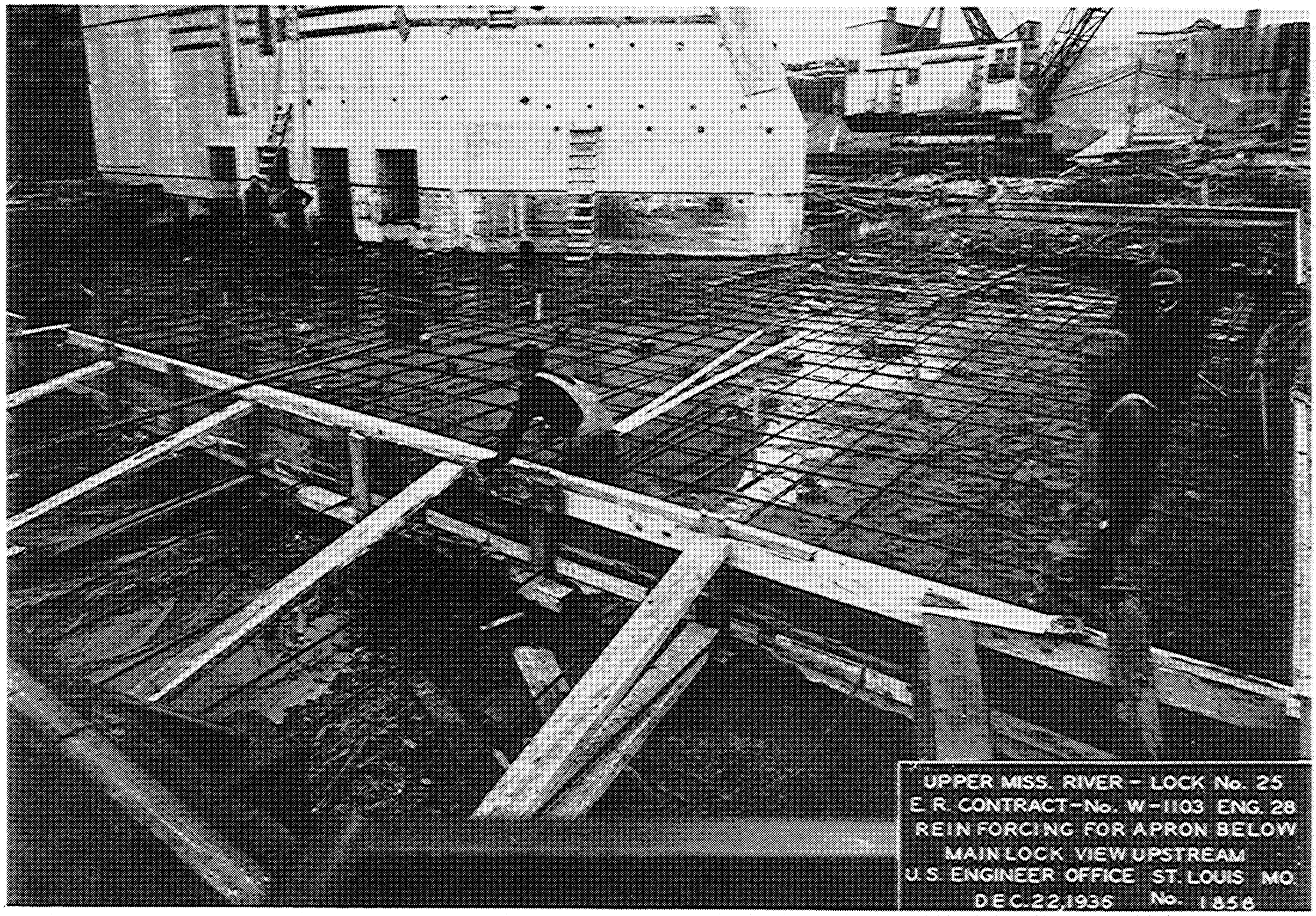
General Setting: Lock and Dam No. 24 is located 93.5 miles upstream from St. Louis. The river in this location is normally 1,650 feet wide, but during high water it inundates the flood plains of the Illinois shore as far as the levee of the Sny Island Drainage & Levee District, approximately 3,800 feet from the Missouri bank of the river. The natural channel crosses to the Illinois side of the river a short distance above the lock and dam complex, and recrosses to the Missouri side just below the site.

Dam: The 1,340-foot long movable dam has 15 submersible Tainter gates, 25 feet high and 80 feet long. The gates are raised and lowered by individual electric motors, connected by line shafting to link-chain hoists, located beneath the dam service bridge. The piers provide support for both the Tainter gates and the steel deck girder service bridge that extends the length of the dam. The dam system also includes a 2,720-foot submersible dike.

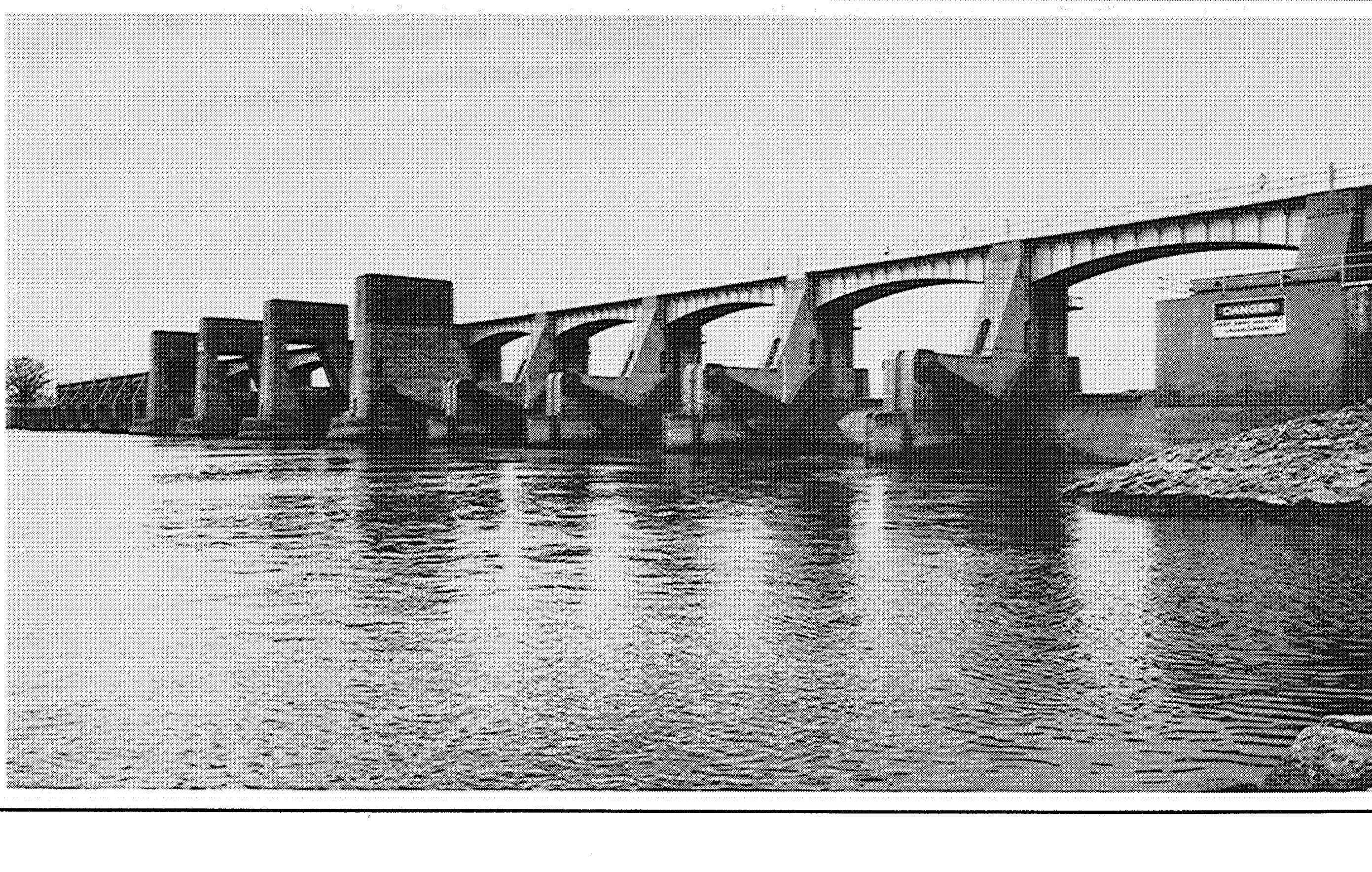
Lock: Lock dimensions are the standard 100 by 600 feet, with the upper gate bay section of an auxiliary lock. Average lift is 15 feet. Unlike Locks Nos. 25 and 26, which are pile-founded structures built atop sand and gravel, Lock No. 24 is founded on durable shale. Because of the presence of a firm foundation material, the lock chamber is not floored and no lateral struts were provided to stabilize the intermediate and river walls.

History/Significance: The submersible, elliptical Tainter gates of Dam No. 24 represent the apex of gate design achieved during the 9-Foot Channel Project. At the time of their construction, the Corps of Engineers believed these gates to be the largest Tainter gates ever constructed. Because of the large size of the Tainter gates, and the relatively ice-free conditions of this stretch of river, roller gates were eliminated entirely from the dam design.

General Contractors:
Lock and Dam: Central Engineering Company, Davenport, Iowa.[36]



(Above) Construction of Lock No. 25, December 1936. (U.S. Army Corps of Engineers, St. Louis District)
(Below) Dam No. 25. (John P. Herr, John Herr Photography)



Lock and Dam No. 25

Date of Construction: 1935-1939

Location: Winfield, Missouri

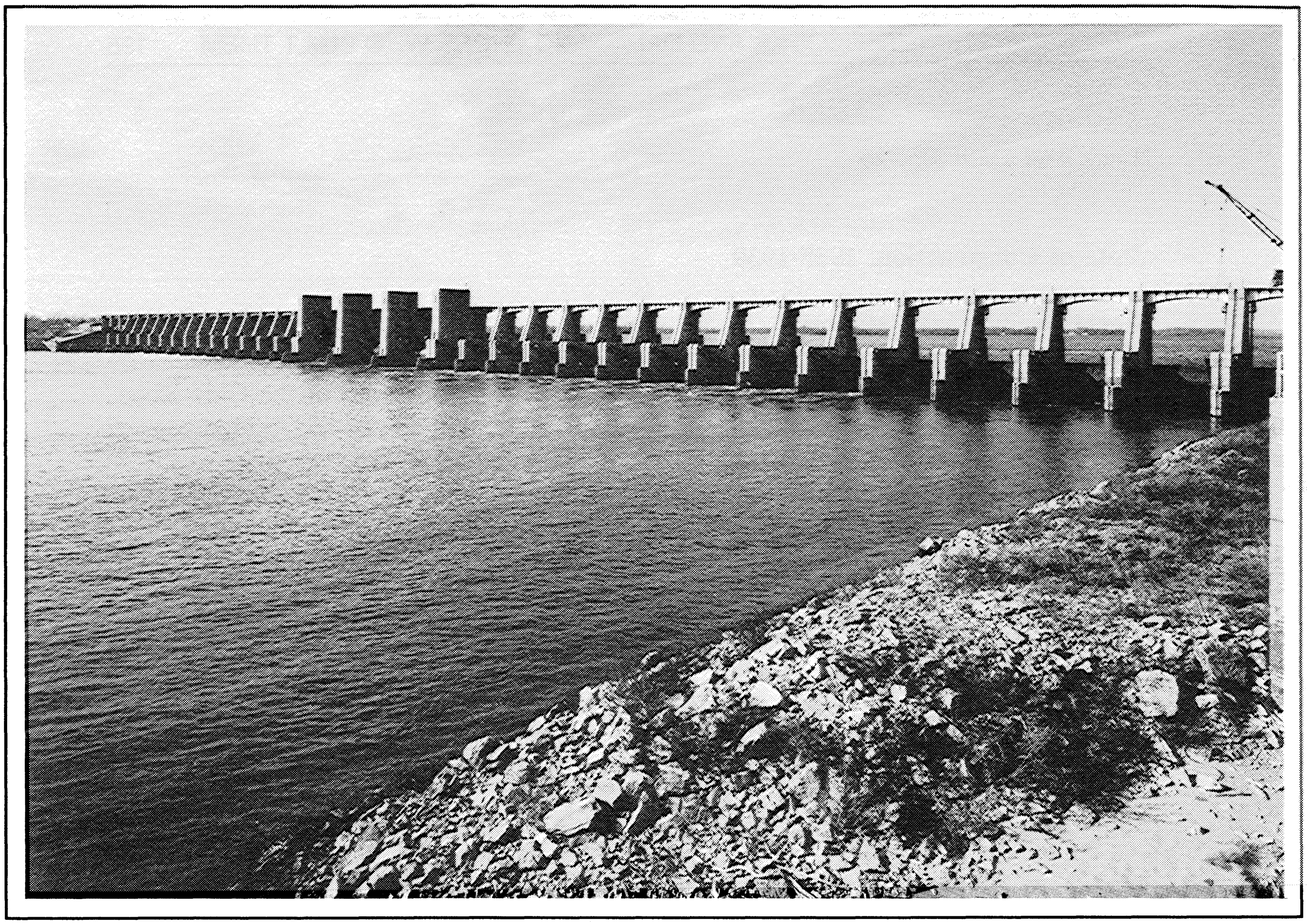
General Setting: The site is located 241.5 miles above the mouth of the Ohio River. The locks are on the eastern shore of Bradley Island; a roadway and bridge connect Bradley Island with the Missouri mainland. The movable dam extends westward 1,296 feet to an abutment on the west shore of Maple Island. A submersible earth dike, 2,566 feet in length, connects Maple Island to the bluffs along the Illinois shore.

Dam: The 1,296-foot long movable portion of the dam has 3 submersible roller gates, 25 feet high and 100 feet long, and 14 submersible Tainter gates, 25 feet high and 60 feet long.

Lock: The installation consists of a main lock, located against the east bank of Bradley Island, and the upper gate bay of an auxiliary lock. The main lock is the standard 110 by 600 feet. The average lift is 15 feet. Both the lock and the movable dam are pile-founded structures.

History/Significance: The Tainter gates of Dam No. 25 represented a marked advance over those installed at Dam No. 26. The gates were fully submersible to a depth of nearly 8 feet, more than twice that attained at Dam No. 26. Additionally, the streamlined spillway that characterized the Dam No. 26 gates was replaced by a riveted steel sheet that entirely covered the gate's steel framework, protecting it from ice damage and providing a smooth unobstructed surface for the water to pass over the gate in its submerged position.

General Contractors:
Lock and Dam: United Construction Company, Winona, Minnesota[37]



Dam No. 26. (John P. Herr, John Herr Photography)

Lock and Dam No. 26

Date of Construction: 1934-1938

Date of Demolition: 1990

Location: Alton, Illinois

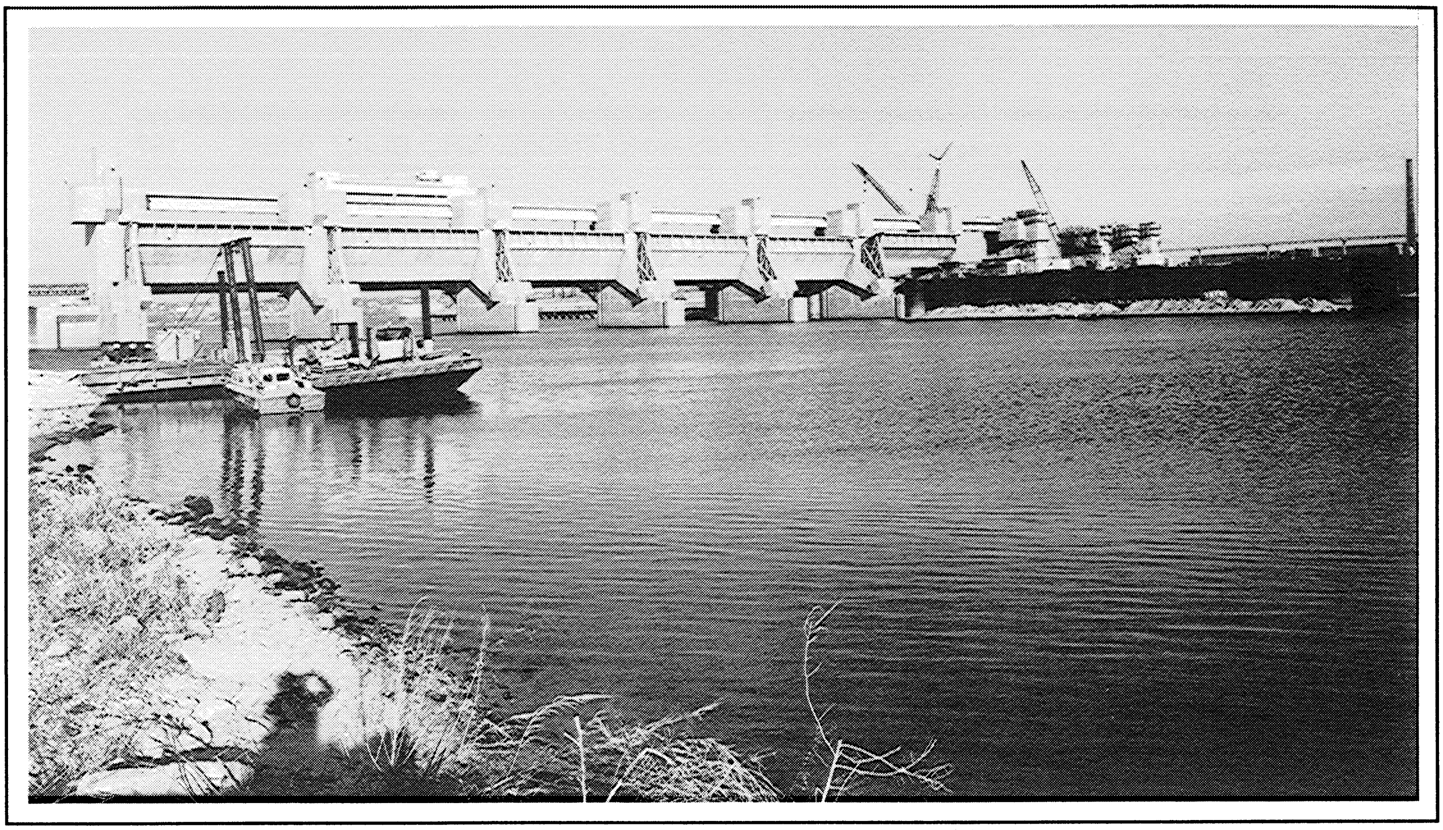
General Setting: Lock and Dam No. 26 was located approximately 22 miles above St. Louis, Missouri. The complex was immediately upstream from the Missouri & Illinois Bridge & Belt Railway bridge. The locks were on the eastern side of the river. The movable dam extended westward from the river wall of the twin locks approximately 1,724 feet to the abutment on the Missouri side of the river. Adjoining the abutment at an angle, an earthen dike extended nearly 900 feet to the embankment of the Missouri & Illinois Bridge & Belt Railway.

Dam: The movable portion of the dam, which was 1,725 feet in length, had 3 submersible roller gates, 25 feet high and 80 feet long, and 30 submersible Tainter gates, 30 feet high and 45 feet long.

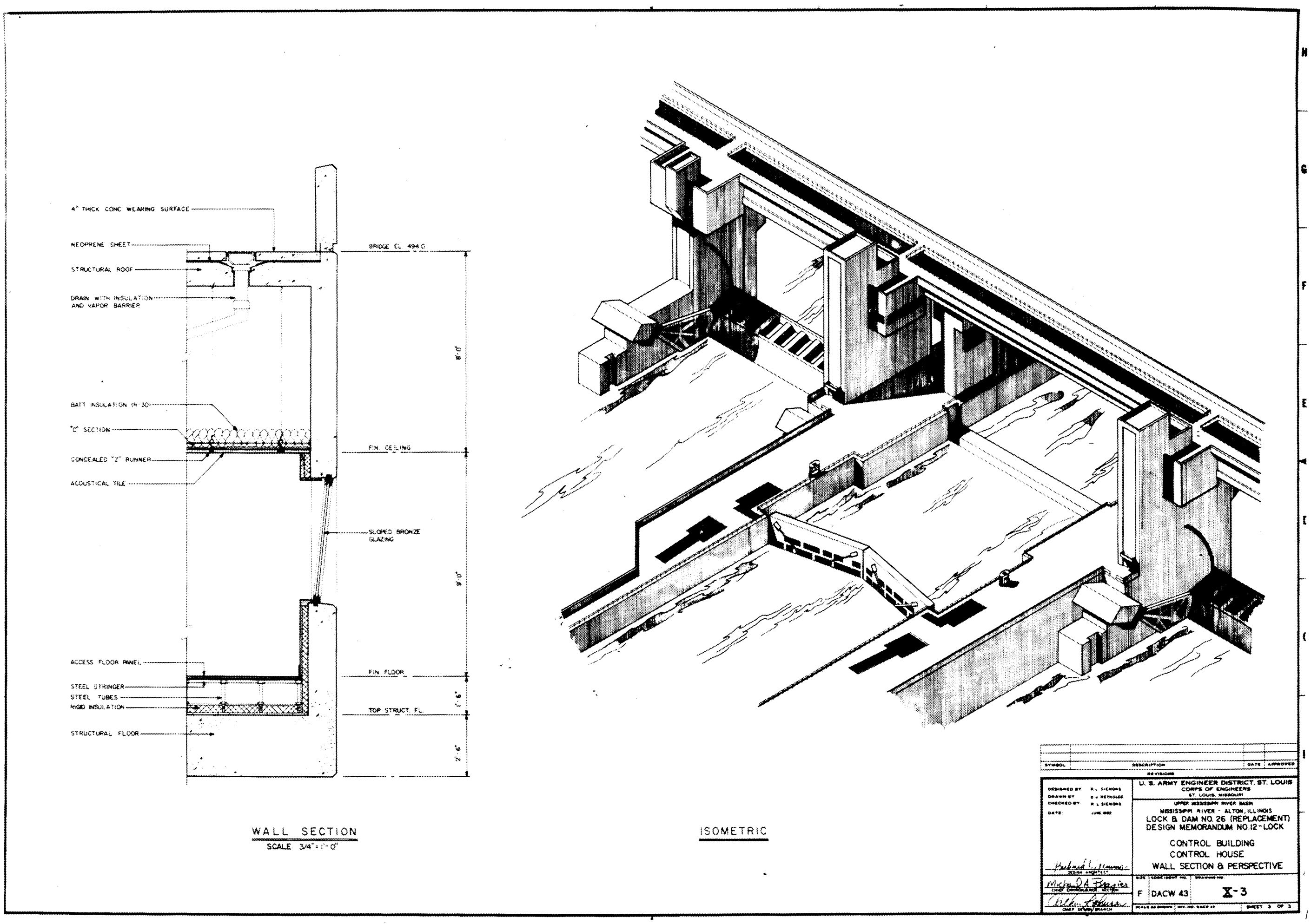
Lock: The installation included a main lock and an auxiliary lock. The main lock measured 110 by 600 feet; the auxiliary lock was 110 by 360 feet.

History/Significance: Lock and Dam No. 26 was the first 9-foot channel installation designed and built in the St. Louis District. It was also the first 9-foot channel installation that was replaced by a modern structure. Lock and Dam No. 26 suffered severe structural deficiencies and was incapable of accommodating the river's increasing traffic. As a result, the structure was torn down in 1990, and replaced by Lock and Dam 26R.

General Contractors:
Lock: John Griffiths & Son Company, Chicago, Illinois
Engineering Construction Company, Delaware
Dam: Engineering Construction Company, Delaware[38]



(Above) Dam No. 26R. (John P. Herr, John Herr Photography)
(Below) Construction Drawing for Lock and Dam No. 26R, ca. 1980. (U.S. Army Corps of Engineers, St. Louis District)



Lock and Dam No. 26R
(Melvin Price Lock and Dam)

Date of Construction: 1979-1990

Location: Alton, Illinois

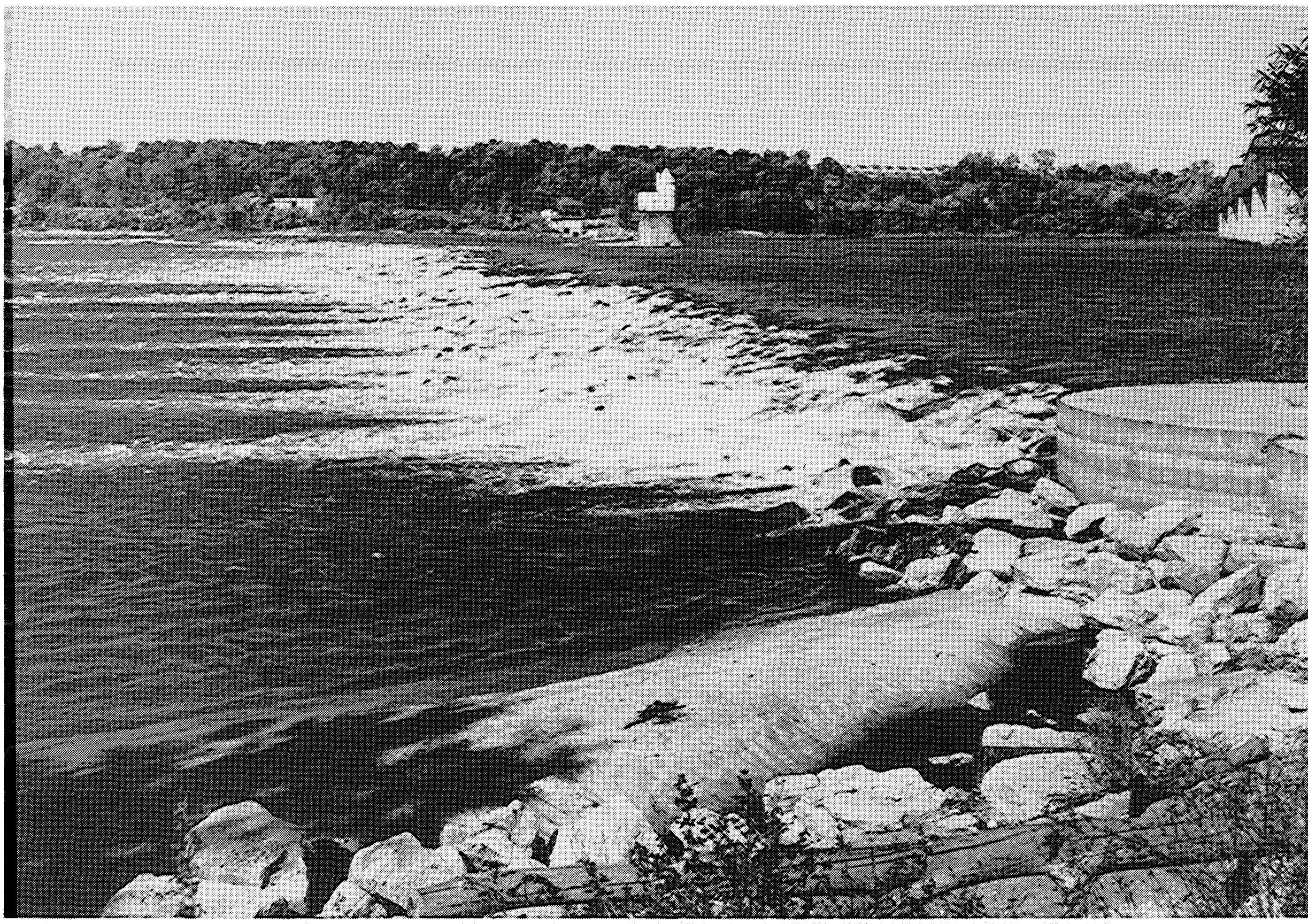
General Setting: Lock and Dam No. 26R is located 2 miles below the site of the old Lock and Dam No. 26, which was razed in 1990.

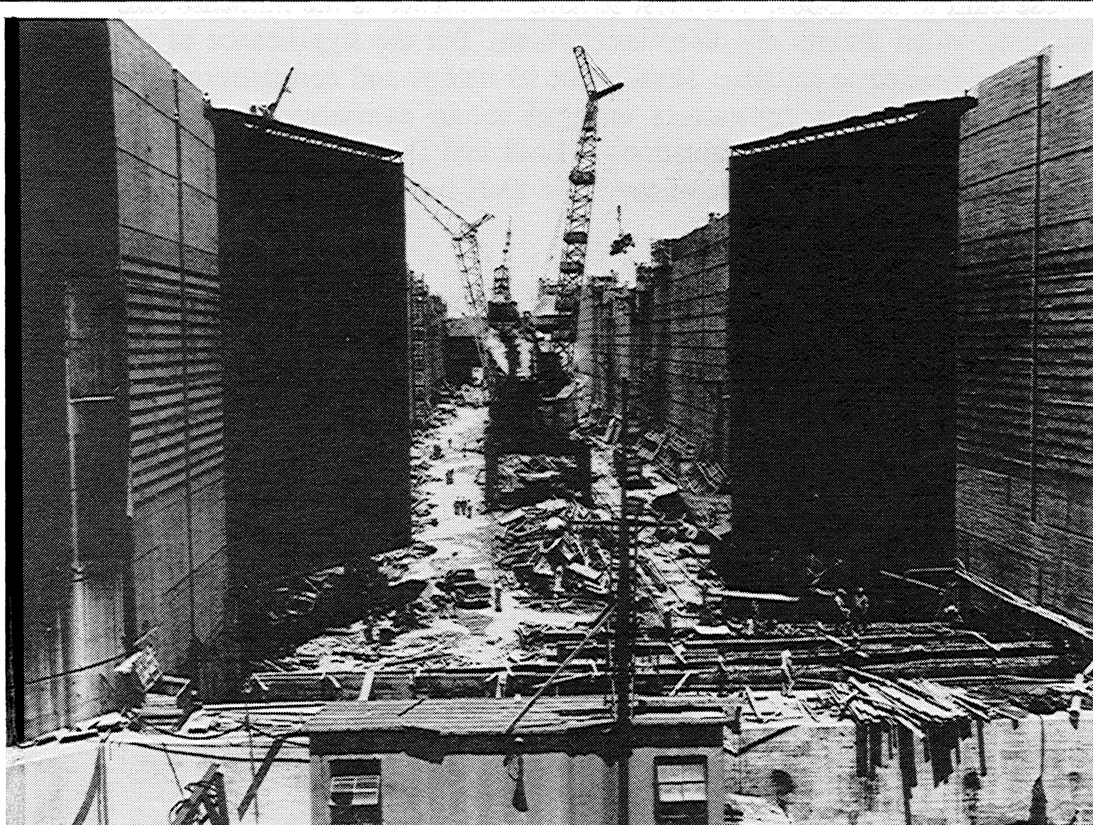
Dam: The movable dam has 9, open-frame, non-submersible Tainter gates, each 42 feet high and 110 feet long. Individual, electrically-operated, cable hoists are housed in pier-top operating houses. The 1,160-foot long movable dam is supported by steel H-piles driven to bedrock.

Lock: The installation has twin locks. The main lock is 110 by 1,200 feet; the auxiliary lock is 110 by 600 feet. The main lock is U-shaped, and is supported on steel H-piles. The maximum lift is 24 feet.

History/Significance: Lock and Dam No. 26R constitutes the first replacement of an original installation of the 9-Foot Channel Project. The basic components of the complex are similar to those built in the 1930s. The most striking difference is the immense size of the new structure, which dwarfs the older installations. But the significance of the new installation is not limited to its size. Throughout its design and construction, the Corps of Engineers and various contractors engaged in an extensive program of computer-assisted design, testing, and evaluation on Lock and Dam No. 26R to create a structure that represents the present state-of-the-art in river navigation control works.

General Contractors:
Lock: Joint venture of S.J. Groves & Sons Company, Minneapolis, Minnesota;
Guy F. Atkinson Company, South San Francisco, California; and
Dillingham Corporation, Pleasanton, California
Dam: Joint venture of S.J. Groves & Sons, Minneapolis, Minnesota;
Guy F. Atkinson Company, South San Francisco, California;
Ball Construction Company; and
Black & Veatch.[39]





(Above) Dam No. 27, also known as the Chain of Rocks Dam, is a fixed, low water dam. The Chain of Rocks Bridge and St. Louis Water Department Intake are in the background. (John P. Herr, John Herr Photography)

(Left) Construction of Main Lock No. 27, June 1950. (U.S. Army Corps of Engineers, St. Louis District)

Lock and Dam No. 27

Date of Construction: 1947-1964

Location: Locks: Granite City, Illinois
Dam: St. Louis, Missouri

General Setting: The locks are located near the southern end of the 8.4-mile long Chain of Rocks Canal, and 185.5 miles above the mouth of the Ohio River. The dam is located on the Mississippi River, 190.2 miles above the mouth of the Ohio River, immediately downstream from Homer Dike, Intake Tower Nos. 1 and 2 of the St. Louis Water Works, the Chain of Rocks Highway Bridge, and the Interstate Highway 270 Bridge.

Dam: Dam No. 27, also known as the Chain of Rocks Dam, is a non-movable, low water dam, approximately 2,500 feet long, which extends entirely across the river.

Lock: The installation includes twin locks. The main lock chamber is 110 by 1,200 feet; the auxiliary lock chamber measures 110 by 600 feet. Both locks were excavated to bedrock, which serves as the lock chamber floors.

History/Significance: Lock No. 27 represents the first major addition to the 9-Foot Channel Project. The locks are located at the lower end of the Chain of Rocks Canal, which was constructed to allow river traffic to bypass the shallows located at the Chain of Rocks Reach. Construction of the canal began in July 1949, and the canal and locks were opened in February 1953. The main lock is 1,200 feet long, twice the length of the locks constructed as part of the 9-Foot Channel Project of the 1930s. The longer length eliminated the need to break apart long strings of barges. Dam No. 27 was designed to provide additional water depth at the lower gate sills of Lock No. 26. Constructed between 1959 and 1964, the dam has virtually no impact upon operations within the Chain of Rocks Canal or at Locks No. 27.

General Contractors:
Lock: River Construction Corporation
Dam: unknown[40]

CHAPTER TEN NOTES

1.Elliot, "Movable Gates," 3.

2.H.M. Anderly to Alfred W. Rice, December 6, 1940, RG77, St. Paul District, General Records 1934-1943, Box 39, Entry 1629, File 4013.1/28-11 to 4013.1/65, NAKCB.

3.Gjerde, "St. Paul Locks and Dams," 118-128, 161-179.

4.Merritt, Creativity, Conflict and Controversy, 190-203, 206-207, 437.

5.Annual Authorities--Employees--District Engineers, St. Paul, through the Division Engineer, Western Division, May 7, 1929, 1-20; Lieutenant Colonel Wildurr Willing to Chief of Engineers, October 21, 1929, re: Selection of Howard Anderly for Promotion; General Lytle Brown, Chief of Engineers to the Secretary of War, February 27, 1930; Lieutenant Colonel Wildurr Willing to Chief of Engineers, U.S. Army, February 13, 1930; and Memorandum: U.S. Engineer Office, St. Paul, Minnesota, November 18, 1929--Statement to accompany recommendation for increase of pay: Elmer J. Christenson, 2, RG77, subgroup: St. Paul District, Box 8, Entry 1628, Miscellaneous Authorities, (FY 1930) Files 15/385-1 to 15/385-62, NAKCB; U.S. Civil Service Commission Certificate No. 6425, June 8, 1927--Appointment of Elmer J. Christenson as Junior Civil Engineer; Arwood M. Miller, Civilian Personnel Officer to Chairman, Incentive Awards Committee, St. Paul District, CE, U.S. Army, Subject: Recommendation for Special Acts or Service Award, March 1, 1956, 3; and U.S. Army Corps of Engineers, Civilian Personnel File: Elmer J. Christenson, Record Group 146 (unaccessioned), Civilian Records Center, National Archives, St. Louis (hereafter cited as NASL).

6.Personnel Files: Hibbert M. Hill and Martin Nelson, Record Group 146, Civilian Records Center, NASL; Personnel Files: James R. Johnson, Elmer J. Christenson, Edward F. Brownell, Henry J. Manger, Leo M. Buhr, George O. Guesmer, Martin E. Nelson, RG77, subgroup: St. Paul District: Miscellaneous Authorities, (FY 1930) box 8, entry 1628, file 15/385-1 to 15/385-62, NAKCB; Report on Economy in Expenditures in compliance with Circular Letter (Finance No. 173) Office, Chief of Engineers, December 29, 1932, and Letter from Division Engineer, U.M.V.D., January 11, 1933, RG77, U.M.V.D., Organization Planning Files-Permanent #2, Box 9, Para 15-B, SR 345-250-5, NAKCB.

7.Jerome O. Ackerman Collection, American Heritage Center, University of Wyoming, Laramie.

8."History of Construction: Dam Number 3" (St. Paul: U.S. Army Corps of Engineers, St. Paul District, n.d.), typewritten, St. Paul District Office Records; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records; Gjerde, "St. Paul Locks and Dams," 132-136; and Merritt, Creativity, Conflict and Controversy, 206-207.

9."History of Construction: Dam 4" (St. Paul: U.S. Army Corps of Engineers, St. Paul District, n.d.), typewritten, St. Paul District Office Records, 1, 57-68, 80; Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 in the St. Paul District--Overview and Cultural Resources Compliance Report With A Programmatic Memorandum of Agreement (St. Paul: U.S. Army Corps of Engineers, St. Paul District Office, n.d.), photocopy, 8; William Patrick O'Brien, "Photographic Inventory: Locks and Dams 3-10," National Park Service, Rocky Mountain Regional Office, 1987; Gjerde, "St. Paul Locks and Dams," 136-139; Merritt, Creativity, Conflict and Controversy, 206-207; and U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records.

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16."History of Construction: Dam 10" (St. Paul: U.S. Army Corps of Engineers, St. Paul District, July 1938), typewritten, St. Paul District Office Records, 1, 3-8, 13, 21; "History of Construction: Lock 10 (St. Paul: U.S. Army Corps of Engineers, June 1938), typewritten, photocopy, St. Paul District Office Records, 4, 6-11, 17; Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 in the St. Paul District, 15; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records; Gjerde, "St. Paul Locks and Dams," 159-161; and Merritt, Creativity, Conflict and Controversy, 206-207.

17.Tweet, Rock Island District, 379. Unlike Major Hall, Major Edgerton's career prospered after his Rock Island tour of duty. From 1940-44, he served as Governor of the Panama Canal Zone. He then became Deputy Director and, still later (1945-46), Director of Material for the War Assets Administration. In 1946 Edgerton became Director of the United Nations Recovery and Reconstruction Agency in China, a position he held until 1947 when he became a member of the War Department Board. He also served as President of the Corps' Beach Erosion Board before retiring from the Army in 1949. After retirement, Edgerton became Executive Director of the Committee on Renovation of the White House during the Truman Administration. He was president of the Export-Import Bank from 1953-1955, a consulting engineer for the World Bank, and director of several corporations. He died in 1976.

18.Tweet, Rock Island District, 401-401; Johnson, Louisville District, 183; and W.F. Heavey, "Concreting at Ohio River Lock No. 45," The Military Engineer 16 (March-April 1924), 144-146. Not only had McCormick, the Southerner (he was born and educated in Virginia), already served directly under McAlpine, the Yankee (who was born and educated in Massachusetts), but McCormick, at age 54, was more the 56 year-old McAlpine's contemporary and their professional training and experience drew on the same period and styles of engineering. Monroe represented an earlier style.

19.Annual Report 1934, 782; Annual Report 1937, 916; Annual Report 1940, 1152; and Tweet, Rock Island District, 380-381. Following his Rock Island tour, Gesler was in charge of the Contract and Finance Section of the Office of the Chief of Engineers. He served as Mid-Atlantic Division Engineer from 1943-1946. He was Philadelphia District Engineer in 1949 and 1950. He died in 1958.

20.Tweet, Rock Island District, 384, 407, 409; "List of Officers and Others Available for Witnesses," February 4, 1937; "List of Witnesses available to testify on Meltzer Claim Case on Lock 22," May 26, 1941.

21.R. A. Wheeler to Chief of Engineers, May 3, 1934, RG77, Entry 111, Box 977, File 3524, WNRC; "List of Officers and Others Available for Witnesses," February 4, 1937; "List of Witnesses Available to testify on Meltzer Claim Case on Lock 22," May 26, 1941; Tweet, Rock Island District, 401, 271, 416. Once the project was designed, Monroe retired from the Corps in 1937 and McCormick became the head civilian engineer in the Rock Island District. McCormick remained in that position until he retired from the Corps in 1946. However, much of the rest of the engineering staff moved on. By 1941, Silkman was Chief of the Supply Section of the Office of the Chief of Engineers. J. B. Alexander was in Denison, Texas, working on high dams and Abbott was working for the Corps in the Canal Zone. Abbott later transferred back to the Ohio River and became Chief of Engineering at the Ohio River Division in Cincinnati. He finally retired from the Corps in 1970. Johnson to O'Brien, February 6, 1988, 2nd letter of that date, 2, files at the National Park Service, Rocky Mountain Regional Office, Lakewood, Colorado.

22.U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Locks and Dams 9-Foot Channel. (Copies of all the original contract drawings pertaining to each lock and dam complex are on file at that complex, and copies of all the drawings relevant to the 12 complexes in the Rock Island District (11-22) circulate from the central district library vault in the Clock Tower Building Annex in Rock Island, Illinois); "Final Report--Lock 11," 2-4, 6, 24-25, 32, 82-83, 91; "Final Report--Dam 11," 2, 4, 10, 16, 52-53; "Mississippi River Lock and Dam No. 11, Final Report--Construction," Vols. III and IV; "Power, Control and Lighting System" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, July 1940), 2-3, RG77, Entry 81, Box 667, NACB; C.W. Ball to Contract Section OCE, January 5, 1942, RG77, Entry 111, Box 694, WNRC; R.A. Wheeler to Leroy C. Perkins, July 17, 1934, C.W. Ball to Chief of Engineers, June 26, 1941, and January 26, 1942, R.A. Wheeler to Div. Engineer, January 16, 1934, and R.A. Wheeler to Div. Engineer, October 5, 1933, RG77, Entry 111, Box 974, WNRC; interoffice memos, April 27, 1942, and May 21, 1940, E.E. Gesler to Chief of Engineers, January 13, 1937, Harry W. Hill to Chief of Engineers, June 19, 1941, E.E. Gesler to Chief of Engineers, January 13, 1937, E.E. Gesler to R.W. Kaltenbach Corp., April 16, 1937, and E.E. Gesler to Div. Engineer, June 26, 1937, RG77, Entry 111, Box 975, WNRC; "Bids on upper approach deflection dike, June 1941," and "Laboratory Test on Hydraulic Model of Lock and Dam No. 11, Mississippi River, Dubuque, Iowa," by St. Paul Engineer District sub office, Hydraulic Laboratory, University of Iowa, Iowa City: Hydraulic Report No. 40, April 1940, RG77, Entry 111, Box 178, WNRC; Annual Report 1940, 1160; Annual Report 1942, 1025; Annual Report 1947, 1400; Annual Report 1948, 1563; "Lockhouse Rehabilitation Concept Report, Mississippi River" (Milwaukee: Threshold Design, Inc., 1984), passim; Mary Rathbun telephone interviews with Wayne Currier, Lockmaster at Lock and Dam No. 11, January 25 and 27, 1988, and February 2, 1988; and Mary Rathbun interview with Steve F. Ohler, Lockmaster at Lock and Dam No. 18, July 11, 1984.

23.U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Locks and Dams 9-Foot Channel, Rock Island District Records; "Mississippi River Lock and Dam No. 12, Final Report--Construction," Vol. I: "General Introduction and Lock," (Rock Island: U.S. Army Corps of Engineers, Rock Island District, November 1937), (hereafter referred to as "Final Report--Lock 12," 2-4, 20, 22, 85; "Final Cost Report Dam No. 12, Mississippi River" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, October 1939); W.H. Crossen to General Accounting Office, July 23, 1938, RG77, Entry 111, Box 977, File 3524, WNRC; Annual Report 1951, 1237; Threshold, "Lockhouse Rehabilitation;" Currier interviews, Ohler interview; and Annual Report 1939, 1150.

24.U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Locks and Dams 9-Foot Channel, Rock Island District Records; "Mississippi River Lock and Dam No. 13, Final Report--Construction," Vol. I: "Introduction and Lock" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, January 1938), (hereafter referred to as "Final Report--Lock 13"), 11, 20; "Final Cost Report, Lock 13, Mississippi River" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, n.d.), 16-17; "Final Cost Report, Dam 13, Mississippi River" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, December, 1939), C, 6; E.E. Gesler to Chief of Engineers, December 15, 1936, March 31, 1937, June 24, 1938, and March 15, 1938, and E.E. Gesler to Chief of Engineers, November 30, 1935, RG77, Entry 111, Box 979, WNRC; E.E. Gesler to Chief of Engineers, June 2, 1939, RG77, Entry 111, Box 980, File 3524, WNRC; Annual Report 1942, 1028; Annual Report 1950, 1449; Currier interviews; Threshold, "Lockhouse Rehabilitation;" Mary Rathbun interview with Verlin Baker, Lockman at Lock and Dam No. 13, June 27, 1984; Ohler interview; "Final Cost Report, Dam No. 14, Mississippi River" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, December 1939), (hereafter referred to as "Final Cost Dam 14"), C; "Final Cost Report, Dam No. 17, Mississippi River" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, October 1940), (hereafter referred to as "Final Cost Dam 17"), 107; and Annual Report 1940, 1155.

25.U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Locks and Dams 9-Foot Channel, Rock Island District Records; "Mississippi River Lock and Dam No. 14, Final Construction Report," Vol. I: "Introduction, Lock, Temporary Buildings" (Rock Island: U.S. Army Corps of Engineers, Rock Island District, December 1939), (hereafter referred to as "Final Report Lock 14"), 6, 12-13, 20, 74; "Final Cost Dam 14," C; W.H. Crosson to Chief of Engineers, March 31, 1939, M.E. Sorley to Central Engineering Company, November 24, 1936, R.A. Wheeler to Central Engineering Company, August 17, 1935, C.P. Gross to Chief of Engineers, November 20, 1940, E.E. Gesler to Chief of Engineers, June 22, 1939, and E.L. Daley to Chief of Engineers, January 11, 1934, RG77, Entry 111, Box 982, WNRC;

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31.U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Locks and Dams 9-Foot Channel, Rock Island District Records; "Final Report Lock 20," 2, 4, 19-22; "Final Cost Dam 20," 1; Pillsbury to U.S. District Engineer Rock Island, November 26, 1932, E.N. Parker to Chief of Engineers, November 16, 1933, R.A. Wheeler to Division Engineer, September 30, 1933, and June 22, 1935, D.A. Morris to Comptroller General, June 24, 1935, R.A. Wheeler to Chief of Engineers, May 25, 1935, R.A. Wheeler to Fries-Walters, April 8, 1935, R.A. Wheeler to Link Belt Co, April 1, 1935, and December 27, 1934, and R.A. Wheeler to Chief of Engineers, October 31, 1934, RG77, Entry 111, Box 993, WNRC; R.A. Wheeler to the Atlas Car & Mfg. Co., May 7, 1935, and R.A. Wheeler to Division Engineer, March 30, 1935, RG77, Entry 111, Box 992, File 3356; Burt E. Hoover to E.E. Abbott, July 30, 1935, R.A. Wheeler to Lakeside Bridge Co., July 24, 1935, and E.E. Gesler to Division Engineer, January 12, 1938, RG77, Entry 111, Box 994, WNRC; Annual Report 1940, 1160; Annual Report 1942, 1028; Annual Report 1951, 1237; and H. Doc. 137.

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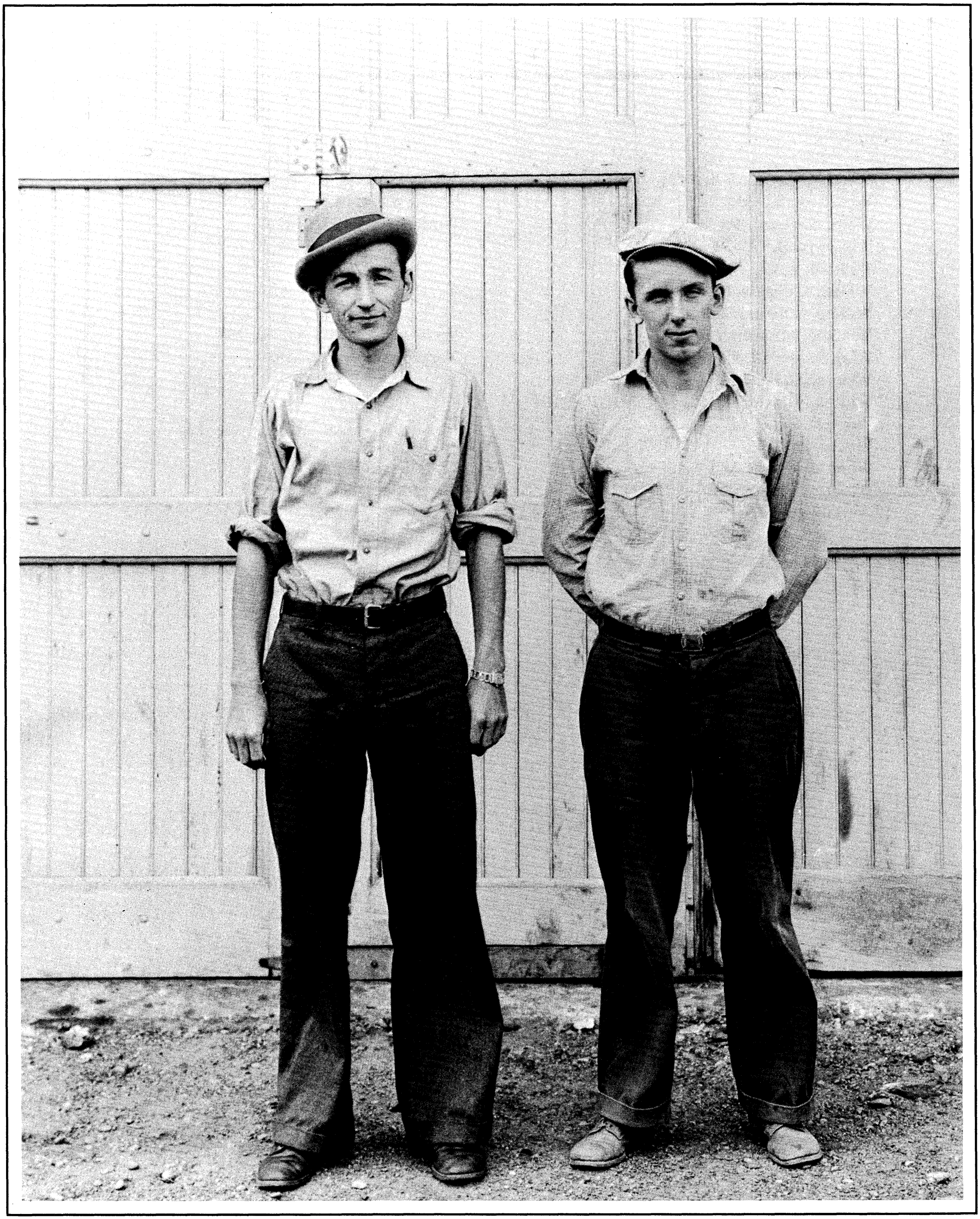

Inspection Personnel, Lock and Dam No. 5A, c. 1936. (American Heritage Center, University of Wyoming)

Acknowledgments

Gateways To Commerce, The U.S. Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River is the second in a series of National Park Service monographs about cultural resources in the Rocky Mountain Region. The first monograph, published in 1989, focused on archaeological resources within Canyonlands National Park. Gateways to Commerce, which documents the construction of one of the Nation's largest navigation improvement projects, is the result of three Historic American Engineering Record (HAER) studies that were completed under the direction of the Rocky Mountain Regional Office.

The Historic American Engineering Record program was established in 1969 by the National Park Service, the American Society of Civil Engineers, and the Library of Congress. The purpose of the program is to document the Nation's historic industrial, engineering, and transportation resources, as well as the working and living conditions of the people associated with them. Under the tripartite agreement, the National Park Service administers the HAER program with funds appropriated by Congress and supplemented by outside donations. The Rocky Mountain Regional Office of the National Park Service is responsible for preparing and reviewing HAER documents in a 16-state region encompassing Colorado, Illinois, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, Wisconsin, and Wyoming.

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Researchers wishing to learn more about the 9-Foot Channel Project are encouraged to read the original HAER reports. The reports are located in the Prints and Photographs Division of the Library of Congress in Washington, D.C.; copies are in the files of the National Park Service, Rocky Mountain Regional Office. In addition to containing more detailed information, the HAER reports acknowledge the efforts of the many other individuals, too numerous to mention here, whose work contributed to this publication.

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